Incident reporting in the construction industry: An empirical investigation of the antecedents affecting behavioral intentions

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by

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TO

MY PARENTS

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ABSTRACT

The adoption of electronic incident reporting system (E-IRS) has immense potential to overcome barriers inhibiting effective reporting of incidents in the construction industry. The successful implementation of E-IRS requires a rigorous understanding of system adoption and the factors that may encourage its usage. This research examined the barriers that inhibit the effective reporting of incidents along with the determinants influencing the use of electronic incident reporting systems in the construction industry. The Technology Acceptance Model (TAM) is further extended in the study by integrating social influence, facilitating conditions, trust, and technological self-efficacy as external variables. The proposed model was trialed through the Partial Least Squares-Structural Equation Modeling technique by utilizing empirical data collected from 136 respondents associated with the construction industry. The study findings indicated that trust and perceived ease-of-use were key drivers that govern the acceptance behavior of E-IRS. Moreover, facilitating conditions and technological self-efficacy had a significant positive effect on perceived ease-of-use; while, social influence was found to have a meaningful impact on trust. This study further reinforces the applicability of the TAM coupled with four external variables in forecasting the utility of E-IRS in the construction industry and provided a roadmap for a better understanding of decisive factors affecting at large. In addition, its practical implications were also discussed aiming to step towards digitalization.

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LIST OF ABBREVIATIONS

Acronym	**Definition**
AVE	Average Variance Extracted
AR	Augmented Reality
BIM	Building Information Modeling
CB-SEM	Covariance-Based Structural Equation Modeling
COMR	Composite Reliability
CRA	Cronbach's Alpha
D^2	Mahalanobis Distance
E-IRS	Electronic Incident Reporting System
FC	Facilitating Conditions
HSE	Health Safety and Environment
HTMT	Heterotrait-Monotrait Ratio
ICT	Information and Communication Technology
ILO	International Labor Organization
IT	Information Technology
IN	Behavioral Intention
OH&S	Occupational Safety and Health
PEOU	Perceived Ease of Use
PLS	Partial Least Squares
PLS-SEM	Partial Least Squares Structural Equation Modeling
PU	Perceived Usefulness
Q^2	Cross-Validated Redundancy
R^2	Coefficient of Determination
SPSS	Statistical Package for the Social Sciences
SRMR	Standardized Root Means Square Residual
SI	Social Influence
TAM	Technology Acceptance Model
T	Trust
TSE	Technological Self-Efficacy
TPB	Theory Of Planned Behavior
TRA	Theory Of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

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Chapter 1

INTRODUCTION

This chapter presents the rationale for the study. Starting with a brief overview of the research it moves forward to the problem statement which is enunciated based on the gap that has been identified in the literature review. Then, the objectives of the research are delineated, followed by the significance of the study as to how it will benefit and its relevance to the national needs.

1.1. Brief Overview

The construction sector is viewed as one of the most hazardous industries due to poor health and safety records worldwide (Umar, 2017). Despite numerous significant and quantitative developments in recent decades, the overall health and safety situation continued to be alarming in the construction industry (Ahmed, 2013). The fact that workplace incidents are not thoroughly reported and investigated is one of the major reasons for prevalent occupational health and safety concerns in the construction industry. (Viby Indrayana *et al.*, 2020). Incident reporting is fundamental since it raises the organization's awareness about the circumstances that can turn out severely so that preventative and corrective actions can be taken promptly. Even though it was intended to improve workplace safety, there are still various reasons employees' refuse to comply and avoid reporting (Martowirono *et al.*, 2012). Data related to incidents and dangerous occurrences are often not shared, due to numerous organizational and individual barriers (Rossignol, 2015). The knowledge acquired from such construction failures is, therefore, insufficiently organized and only accessible to a limited number of persons (Ortega, 2000).

According to recent findings, advancement in information and communication technology (ICT) has given rise to significant modifications in traditional reporting practices (Levtzion-Korach *et al.*, 2009) and the use of electronic incident reporting systems (E-IRS) can make a significant contribution to overcoming barriers in the incident reporting (Al-Rayes *et al.*, 2020). However, the adoption of new technology is an arguable subject (Akbari *et al.*, 2020) and many theories of human behaviors have been developed to study the acceptability of novel technologies (Venkatesh *et al.*, 2012). Among these theories, the Technology Acceptance Model (TAM) (Davis, 1989), the Theory of Planned Behavior (TPB) (Ajzen, 1991), the Innovation Diffusion Theory (IDT) (Rogers, 2003), and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.*, 2003) were discovered to be extensively recognized by researchers in demonstrating the key determinants of new technology (Akbari *et al.*, 2020; Rahman *et al.*, 2017). Moreover, the construction industry has developed a reputation for being slow to adopt novel technologies, as well as being resistant to accepting change and innovative ideas (Elshafey *et al.*, 2020). The benefits of new technology will only reap when the end-users of the system utilize the services, and therefore, their intentions towards the new technology are significant in the successful implementation of the system. Previous studies have examined the domain of incident reporting from the perspective of system characteristics (Gnoni and Saleh, 2017; Ortega, 2000; Qureshi *et al.*, 2021; Umeokafor *et al.*, 2020), performance analysis (Al-Aubaidy *et al.*, 2019; Cambraia *et al.*, 2010; Maslen *et al.*, 2020; Sandberg and Albrechtsen, 2018; Saurin *et al.*, 2015), and legal aspects (Oswald *et al.*, 2018; De Silva *et al.*, 2018; Viby Indrayana *et al.*, 2020) in the construction industry. However, no reliable study has been undertaken so far to assess the facets influencing behavioral intent to utilize an E-IRS. Therefore, to foster the adoption of E-IRS in the construction industry, it is primarily important to investigate the factors facilitating their usage behavior.

The goal of this research is to address the knowledge gap by establishing a research model that uses TAM as the principal theoretical basis to examine the key factors influencing E-IRS acceptance in the construction industry of developing countries. The proposed research model is empirically validated using Partial least squares-based SEM (PLS-SEM) based on the data analysis collected through an online questionnaire survey. The research is crucial because the developed TAM findings state the specific factors that influence E-IRS acceptance. Subsequently, when adopting or developing a new E-IRS, identified factors will be valuable to both construction organizations and software developers.

1.2. Problem Statement

Despite the construction industry's rapid growth in recent years and advancements in construction technology, workers are still facing vulnerable safety conditions. Due to the presence of a weak administrative framework, the safety of workers is not the main objective of the construction industry (Raheem and Issa, 2016). One of the critical factors to mitigate risks at the workplace and to improve workers' safety on the construction sites is through better understanding the causes of work-related accidents as each failure provides knowledge that can be used to avoid similar incidents from occurring (Ortega, 2000). Therefore, to avoid construction failures, these must be studied systematically. Information acquired from such investigations should be coordinated and made accessible to all concerned stakeholders to give awareness on issues of particular concern. However, the construction industry lacks widespread incident reporting and investigation due to numerous reasons. Moreover, it has developed a reputation of being slow in adopting change and accepting innovative ideas that digress the traditional approach. Therefore, before implementing any solution that would cater to the safety needs such as an electronic incident reporting system, it is crucial to look into the user's adoption of the new system and the factors that would influence the adoption behaviors.

1.3. Research Objectives

Following are the objectives which this study aims to achieve:

1. To identify barriers that inhibit effective reporting of incidents in the construction industry.
2. To measure the behavioral intention to use an electronic incident reporting system (E-IRS) in the construction industry.
3. To investigate factors influencing the use of E-IRS in the construction industry of developing countries based on the technology acceptance model.

1.4. Research Significance

This research contributes literature in the field of "health and safety" and "information system". The productive use of incident reporting in the construction industry could promote safer construction practices. The information extracted from failure analyses can be efficiently coordinated and made available to all interested parties so that occurrence of similar events could be avoided in the future. Furthermore, communicating risks, hazards and potential threats to all affected and concerned employees in an organization helps in shedding light on possible dangers that may occur. This study provides insight into the barriers that obstruct the effective recording of incidents and suggests the use of an E-IRS for efficiently eliminating barriers to promote a culture of reporting in the construction industry. Furthermore, the development of the model would enhance the understanding of behavioral intentions towards the usage of E-IRS and the factors influencing its usage. When adopting or developing a new E-IRS, identified factors will be useful for construction organizations as well as for software developers for successful implementation of the system. The findings of this research provide a theoretical foundation for construction safety managers, designers, and all the interested stakeholders to take productive measures to vitalize the use of E-IRS in the construction industry of developing countries, thereby reducing the likelihood of construction-related incidents.

1.5. Relevance to National Needs

The construction sector of Pakistan is in a developing stage and requires the adoption of several standard practices to compete with the international market. The global construction industry has shifted its focus to the use of computers and other IT services as a part of their business, but similar practices are lacking in our industry. In Pakistan, the prevailing occupational health and safety standards are regulated by the Factories Act of 1934 and the Government of Pakistan labor policy 2010. These state laws, which are not specific to the construction sector, are largely concerned with the occupational health and safety of factory workers (Raheem and Issa, 2016). The study would serve to enhance the knowledge about incident reporting to benefit stakeholders in understanding barriers and determinants of incident reporting; leading to the improved safety performance of construction projects. There is a need to develop an extensive understanding of behavioral intentions towards the use of E-IRS particularly concerning the construction industry of Pakistan whereby incident reporting is not the focus to avoid similar future occurrences. In our society where incident reporting and investigation are not taken seriously, this study will serve as a guide to the relevant stakeholders in encouraging the effective reporting of incidents. Thus, providing a safe working environment for millions of construction workers of Pakistan’s construction sector.

1.6. Thesis Organization

The thesis is divided into six chapters, the first of which is an introduction to the research topic along with the problem statement, research objectives, research significance, and relevance to national needs. Chapter 2 provides a detailed literature review on construction safety and health, incident reporting, and technology acceptance model. The research methodology employed in the study to meet the research objectives is covered in Chapter 3. Barriers to effective incident reporting were validated using the questionnaire survey by field experts and the use of E-IRS is justified. Chapter 4 presents the theoretical background and research hypotheses. A model is then proposed based on the research hypotheses, which are further tested in the next chapter. Chapter 5 enlighten the study design and analysis. It explains the questionnaire design, data collection, and analysis using the partial least squares SEM technique. The final chapter consists of theoretical and practical implications, conclusions about the research work along with recommendations for future study.

Chapter 2

LITERATURE REVIEW

This chapter comprises detailed literature about health and safety in construction, incident reporting and the barriers inhibiting effective reporting of incidents, the utilization of the Technology Acceptance Model, and its approach in managing and identifying the behavioral intentions of the end-users for the system usage. This chapter integrates all necessary information for a thorough grasp of the concepts and significant findings for conducting the research project.

2.1. Construction Safety and Health

According to the International Labor Organization (ILO), each year roughly 2.78 million people lose their life due to work-related accidents and other occupational diseases (ILO, 2018). This equates to 7616 deaths per day. Moreover, it has been estimated that the number of incidents and illnesses per year is 374 million, which results in employees being absent from work for extended durations (ILO, 2018). Even though each life is valuable and cannot be monetized, the ILO assumes that the yearly economic loss of inadequate occupational and health practices to be 3.94 percent of GDP. Moreover, the Safe Work Australia statistics indicate that the economy of Australia suffered a total of AUS$ 61.8 billion from the year 2012 to 2013 due to work-induced injuries and ailments, accounting for 4.1 percent of Australian GDP (Safe Work Australia, 2017).

The construction sector is regarded as one of the most unsafe (Choudhry and Zahoor, 2016). According to International Labor Organization figures from 2015, more than 100,000 employees expire on construction sites each year as a result of various occupational health and safety issues. Subsequently, it translates that the figure of per day deaths on construction sites is approximately equal to 274 deaths. This number of 274 deaths accounts for approximately 30 percent of all occupational mortality rates. According to the statistical data, construction workers in developed countries are three to four times more likely to die on the site than workers in other industries (Choudhry and Zahoor, 2016). Furthermore, construction-related deaths in underdeveloped countries are three to six times more than in developed countries (ILO, 2015). Due to these poor safety records, the industry persisted at the top position in most countries concerning worker deaths. For example, previous records showed that the construction industry in the United States (US) had 991 deaths accounting for the largest rate of worker deaths in the year 2016. This also indicates a 6% rise in death toll when compared to figures in the year 2015 (BLS, 2018). This figure of 991 deaths in the US also reflects 20% of all worker deaths in the United States.

2.2. Construction Related Accidents

Accident causes in construction have remained a popular topic for researchers working in the domain of construction management. This may be because this realm is perceived to significantly impact the reduction of accidents; if the management dealing with the specific construction project develops effective strategies on how to avoid the reoccurrence of accidents in their future projects (Umar, 2019). To establish an accident prevention strategy for a certain construction project, it is required to first understand the prevailing underlying root causes of accidents (Jones *et al.*, 1999). Construction, as stated in the preceding literature, is one of the largest industries in the United States; nevertheless, if we look into the construction-related accidents it accounts for 20.77 percent of overall fatalities. The Occupational Safety and Health Administration (OSHA) data indicates that 582 workers died due to four distinct causes, contributing to nearly 60% of all construction-related fatalities (OSHA, 2016). These four causes were as follows: falls from heights, being struck by an object, electrocutions, and being caught in or between.

Organizations dealing with safety and health, such as HSE (UK), OSHA (USA), and Safe Work (Australia), play a substantial character in driving a country's safety and health performance. These administrations become the primary source of health and safety statistics reflecting the industry's safety record. However, there are no such organizations in developing countries. Even if such groups exist, they are either not fully functional or are not functioning properly. Hence, forming it one of the most pressing issues in this region, as emphasized by Umar and Wamuziri, (2016). They also addressed how to turn this difficulty into an opportunity by forming a national independent health and safety organization. If the motives for accidents in the construction are recognized at either project, organizational, or national levels, they can be employed to design strategies and initiatives for eliminating or reducing a direct source of future reoccurrence. Any approach or strategy to ideally disregard or diminish the origins of accidents without first identifying the roots will be ineffective and may confuse stakeholders and organizations. However, merely identifying the causes of accidents is not sufficient for an effective plan that can assist in reducing the number of accidents in construction. For instance, if a building project records several accidents caused by falls from great heights, then merely this information is not adequate to develop an efficient policy to limit the accident statistics. The reason i.e., falls from heights will need to be looked into further. Although this rationale seems to be a prominent origin of accidents in the field of construction, it is important to understand and look into the factors which contribute to this cause. It is critical to understand the source of the negligence that contributed to the mishap. Job pressure, tiredness, work history, and inadequate visibility are all some of the examples resulting in negligence. Furthermore, it should be the primary obligation of senior management to provide sufficient training to employees and empower them to avoid risk at work (Umar, 2019).

Mitropoulos' (Mitropoulos *et al.*, 2005) model indicates the need for two significant accident countermeasures: a) effective planning and control to lessen the uncertainty of tasks, and b) error management to improve employees' abilities to trap, avoid, and ameliorate errors. According to a Ugandan study that identified the causes of accidents in the construction business, the leading causes were identified as poor supervision, use of less-skilled employees, and the use of improper construction practices (Lubega *et al.*, 2000). According to the findings of Umar, (2019), accidents are caused by a variety of reasons, including;

1. Inadequate understanding of safety regulations
2. Failure to implement safety regulations
3. People participating in building projects have a low concern for safety
4. Recruiting unskilled employees
5. Construction machinery/equipment failure
6. Stress, including physical and emotional
7. Chemical impairment.

Workers' negligence, poor site management, working at high elevation, failure to conform work procedures, operating equipment without safety devices, low knowledge and skill level of workers, harsh work conditions, poor workers' attitude toward safety, and failure to use personal protective equipment are the main causes of construction accidents, according to research conducted in Malaysia (Hamid *et al.*, 2008). They also suggested that cultural and numerous design mechanisms create workplace environments and give rise to the acts and conditions that contribute to accidents. It is believed that paying attention to the underlying factors will be required to make long-term improvements in sustainable construction practices.

2.3. Overview of Incident Reporting

2.3.1. Defining Incident

An incident is defined as a potentially hazardous occurrence that has the likelihood to cause a misadventure or has the potential to have serious effects resulting in loss or damage to human life and property (Rossignol, 2015). Further, a "near-miss" is defined as any action that could result in some negative out-turn but did not. Near-misses can also range from a partial breach of safeguards to circumstances in which all existing controls were bypassed but no real losses were inflicted (Reason, 1997). In other words, *"…. they span the gamut from benign events in which one or more of the defenses prevented a potentially bad outcome as planned, to ones that missed being catastrophic by only a hair's breadth. The former provides useful proactive information about system resilience, while the latter is indistinguishable from fully-fledged accidents in all but the outcome, and so fall squarely into the reactive camp*" (Reason, 1997).

Furthermore, internal investigations of near misses should be an inherent element of a large hazard facility's safety management system. Safety incident reporting and investigations should try to prevent future mishaps and occurrences of similar situations (Jones *et al.*, 1999). He went on to say that definitions are vital for understanding the phrases commonly used in industry when discussing occurrences, and they are also significant when contemplating European legislation. Following are the definitions that will help in better understanding the terms used in this thesis:

a) Major Accident is defined as an occurrence such as a huge emission, fire, or explosion caused by uncontrolled developments during the operation of any establishment protected by the Seveso Directive, resulting in immediate or temporarily halted danger to human health and/or the environment, in or out of the establishment, and involving one or maybe more harmful toxins.

b) An accident is defined as an unfavorable incident that causes injury or loss.

c) Major Near Miss is a dangerous scenario in which the planned safety mechanisms have proven insufficient or inefficient, the consequences of which may reasonably be expected to result in a major accident if the chain of events had not been prevented by other methods.

d) An Incident is termed as any unfavorable occurrence, including accidents and near misses.

e) Near Miss is a potentially hazardous condition, occurrence, or harmful behavior in which the chain of events could have resulted in a disaster if not halted.

f) The direct cause is the immediate cause of an incident. Typically consists of harmful site circumstances or unsafe behaviors by an individual.

g) The root cause is the underlying factors that allow the hazardous event to emerge. Removing the root cause will prevent the accident from happening again.

2.3.2. Incident Reporting

Incident reporting is an approach to prevent future incidents and accidents to occur by learning from previous events (Rossignol, 2015). While incidents may occur in all industries, the construction industry is notorious for having high accident rates leading to increased absenteeism, decreased productivity, permanent disabilities, and even fatalities (De Silva *et al.*, 2018). It has been observed that workers in the construction sector are approximately three times more likely to die and two times more likely to be injured at the workplace compared to other industries (Sherratt *et al.*, 2013). Incidents need to be investigated in order to gain quantitative insights into the root cause of the problem (Van

Der Schaaf and Kanse, 2004), to strengthen the safety culture (Saurin *et al.*, 2015), and to reduce the likelihood of reoccurrence of the incident (Maslen *et al.*, 2020) by taking necessary preventive actions. Hinze *et al*. (2006) stated that the actual benefits of administering detailed analyses on incident information received are accomplished when causation patterns and opportunities for prevention are thoroughly acknowledged. The information obtained can then be utilized to execute safety solutions and measures targeted to eliminate future reoccurrences of similar events. According to studies in the construction industry (Shannon and Lowe, 2002), the healthcare sector (Staender, 2011), and the chemical industry (Jones *et al.*, 1999), it has been concluded that the higher the number of near-misses reported, the lower the accident rates likely to be. There is an imminent need for a productive and functional incident reporting system that would act as a keystone of safe health practices and would assist in improving worker safety in the construction industry. The productive execution of an incident reporting system in construction could thus lead to safer construction practices.

According to van der Schaaf (1991), the iceberg model depicted in **Figure 2.1** shows that near misses are "trapped" between genuine, but rare, accidents at the top and an immense number of errors and escapes at the bottom. The assumption is that incident propagation proceeds from the bottom up, which means that the possibilities of early safety programs reduce as you got closer to the top. It is also anticipated that current investigation tactics will always attempt to go as close to the bottom of the iceberg as feasible, rather than settling for shallow explanations of simply the immediate circumstances leading up to an accident and its short-term repercussions. Another direct implication is that these three aspects of the iceberg are directly linked in the context that they show mainly intertwining sets of "root causes": a better starting level should not result in the analysis identifying an entirely different set of root causes, and should also not result in a substantially different set of recommended actions to address these.

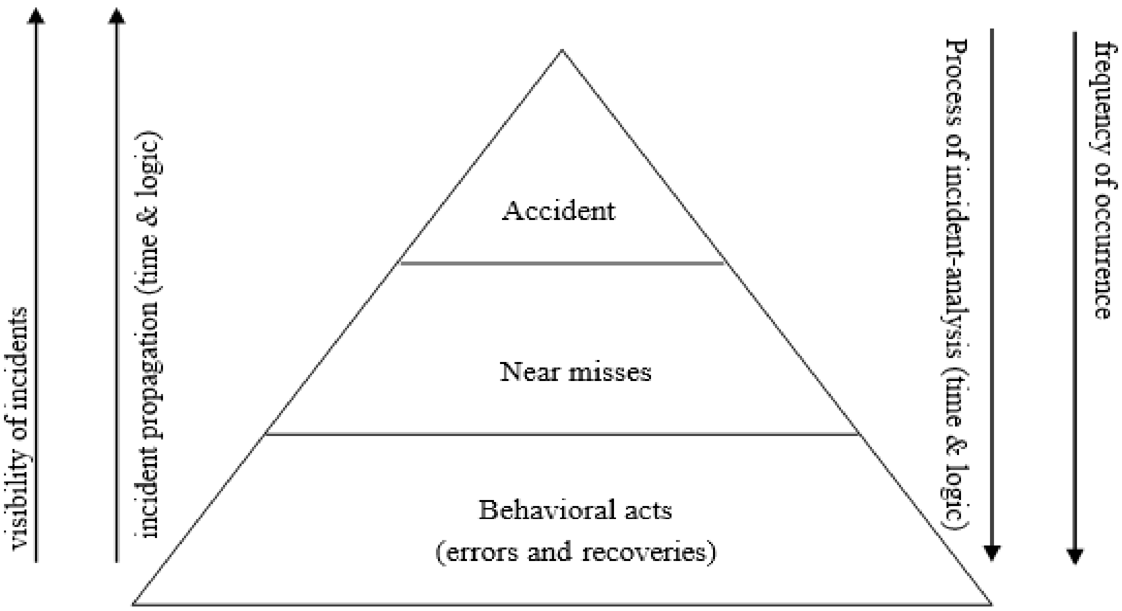

Figure 2.1: Iceberg Model (van der Schaaf, 1991).

According to the "iceberg principle" on the correlation of various types of accidents and near misses, the more near misses (or other abnormalities) you have, the more frequently you will have accidents (Jones *et al.*, 1999). Many firms now see a growth in the number of near misses reported as a good safety performance measure. This is to encourage the near-miss recording and to acknowledge that more near-misses happen than are currently reported. Jones *et al.* (1999) stated that the purpose of internal corporate near-miss reporting is to promote near-miss recording and acquire better insights from them in order to minimize incident recurrence.

2.3.3. Purposes of Collecting and Analyzing Incident Data

According to van der Schaaf (1991), three broad categories of motives for collecting and evaluating near-miss data can be characterized:

1) gaining a qualitative understanding of how (minor) mistakes or errors might lead to near-misses and, in some cases, a real accident
2) to provide statistically reliable analytical insight into the occurrence of causes or combinations of factors that cause an incident
3) to maintain a high level of vigilance toward danger, especially when the incidence of actual injuries and other accidents within an organization are already low.

2.3.4. Advantages of Collecting Incident Data

The benefits of collecting and analyzing near-misses are evident because they provide free lessons (Reason, 1997). If the appropriate conclusions are reached and followed, they can operate as "vaccinations" to stimulate the system's defense against a more significant event in the future, and, just like effective vaccines, they are expected to do so without harming anything or anyone. Further, they offer qualitative acumens into how minor defensive deficiencies might pile up to cause huge tragedies (Stanton *et al.*, 2009). Because they occur more frequently than adverse consequences, they provide the numbers needed for more in-depth quantitative evaluations. Moreover, they also serve as a strong warning of the system's flaws, slowing the process of acute calamity. Nevertheless, for this to happen, the data must be broadly shared, particularly among executives in the organization's highest echelons. This could be further enhanced to shape when each event's information includes a rational estimate of its financial cost to the taxpayers (Reason, 1997).

2.3.5. Barriers to Reporting

Several researchers have worked to mitigate the barriers to effective incident reporting. One of the challenges they observed with cognitive processing of accidents was that information might be filtered selectively before being transferred to higher echelons aimed to minimize liabilities and blame concerns. The attribution of responsibility on the reporter was also cited as a factor hindering the sharing of information in the filter model proposed for incident reporting (Webb *et al.*, 1989). Similarly, Elwell (1995) argued that crew members of the flight may be too guilty to confess their faults, or expect to be penalized, explaining his discovery that human errors, particularly when others have not noticed these, are miss reported in aviation reporting systems. Likewise, in his discourse of factors that could stimulate individuals' adoption of their organization's health and safety culture, and hence the desire to give to the organization's reporting system, O'Leary and Pidgeon (1995) mentioned the fact that legal pronouncements have frequently ignored circumstances resulting in poor performance; that society puts pressure to level allegations and punishments; the military culture in the aviation industry; and the fact that many pilots feel responsible or even guilty for incidents. In line with this, Bridges (2000) claimed that fear of punitive action and teasing by fellow employees are among the key reasons for poor reporting, based on survey results conducted among safety managerial staff of chemical process plants. Furthermore, the firm's concern of potential accountability if the reporting systems are manipulated by outsiders as a possible deterrent against reporting of safety incidents. When this anxiety is communicated to the workers, whether explicitly or implicitly, their willingness to participate suffers badly (Bridges, 2000).

It has been discovered that mishaps might be viewed as "part of the job" in their prolonged analysis of 2367 accidents that happened in four distinct types of industrial garages (Powell, 1971). According to Glendon (1991), the "macho" work climate observed in some industries, such as construction, impeded reporting. Dominant societal views on which certain dangerous occurrences are considered acceptable were also cited as an essential element in reporting behavior (Webb *et al.*, 1989).

Additionally, Beale *et al.* (1994) indicated that management's alleged attitudes have a large impact on reporting levels. In line with this, Van der Schaaf *et al.* (2013) claimed that organizational safety culture and related management approaches influence the forms of near misses reported. Chemical plant safety personnel cited lack of management commitment and an inability to follow through after incidents are reported as causes for inadequate reporting practices (Bridges, 2000). Regarding the aviation sector, O'Leary and Pidgeon (1995) stated that conflicts may have damaged the motivation to report events by lowering trust in management. It is also found that people quickly become dissatisfied with incident reporting when they observed that management does not review and appreciate their reports; and that the reporting rate further suffers when those to whom one must report do not acknowledge the job of the people engaged in the occurrences (Powell, 1971). Moreover, in the same line, Smith *et al.* (2001) have also acknowledged the fact that some occurrences are less likely to be noticed. Although they did not investigate the real reasons for failure to report such events, they did find significant variances (and thus preconceptions in the recording system) between recorded self-reported events and industrial injury events gathered through interviews and carefully designed questionnaires.

The justifications presented in the previous literature for not reporting incidences were all proposed after the corresponding research had already been conducted, or based on observations made earlier in the past, and not essentially during the course of the study. To our knowledge, the only research in which the reasons for not reporting had a significant part in the design of the research was conducted by Clarke (1998). In that study, the researcher questioned train drivers how likely they were to notify each of a standardized set of 12 genuine events. The drivers were given a previously defined set of six plausible causes for not disclosing information in a particular instance: instead of reporting prefer sharing details with the colleagues; to safeguard someone from getting into trouble (refers to category "fear"); a specific type of event is considered part of the job (belong to the group "risk acceptance"); too much documentation is involved in reporting (belongs to the category "practical reasons"); the guilty verdict that nothing would be done about this sort of incident (matches with the category "useless"); or the belief that management would pay no attention (again fits in the category "useless").

Different authors have discussed and listed down the barriers to effective incident reporting. To identify the barriers detailed literature analysis was carried out, the identified barriers were given a literature score based on the frequency of their occurrence in literature and their subjective significance, as assessed by each respective author, on a three-point Likert scale where “1=Low, 3=Medium, and 5=High”. A total of 25 relevant papers were shortlisted for this purpose and a total of 29 barriers were identified. The literature score was calculated for each barrier by finding the product of its frequency and impact score, respectively. The literature score was also normalized before using it for further analysis. **Table 1** shows the barriers to incident reporting along with the literature score:

Table 1: Barriers to Effective Incident Reporting Identified through Literature

Sr.	**Barriers**	**Sources**	**Literature Score**
1	Job insecurity and fear of job loss	(Choudhry and Zahoor, 2016; Gnoni and Saleh, 2017; Maslen *et al.*, 2020; Umeokafor *et al.*, 2020)	0.80

2	Reporting Procedure is not appropriate and time-consuming	(Haslam *et al.*, 2005; Mitropoulos *et al.*, 2005; O’Leary and Pidgeon, 1995; Saurin *et al.*, 2015)	0.76
3	Fear of disciplinary action	(Choudhry and Zahoor, 2016; Mitropoulos *et al.*, 2005; Viby Indrayana *et al.*, 2020)	0.72
4	Acceptance of some hazards as part of routine work	(Haslam *et al.*, 2005; Ortega, 2000)	0.68
5	Confusion regarding what is reportable	(Elwell, 1995; Saurin *et al.*, 2015)	0.60
6	Financial incentives to achieve zero-accident targets	(Gnoni and Saleh, 2017; Viby Indrayana *et al.*, 2020)	0.60
7	Lack of feedback on how information reported has been used	(Ortega, 2000; Saurin *et al.*, 2015; Umeokafor *et al.*, 2020)	0.52
8	Lack of knowledge about reporting requirements	(Gnoni and Saleh, 2017; Mitropoulos *et al.*, 2005; Viby Indrayana *et al.*, 2020)	0.52
9	Lack of management commitment to report incidents	(Ortega, 2000; Van Der Schaaf and Kanse, 2004)	0.52
10	Lack of trust in the anonymity of the IRS	(Bridges, 2000; O’Leary and Pidgeon, 1995; Umeokafor *et al.*, 2020)	0.48
11	Fear of damaging future employment or career progression opportunities	(Saurin *et al.*, 2015; Viby Indrayana *et al.*, 2020)	0.44

12	Lack of safety communication in the organization	(Bridges, 2000; Lingard, 2013)	0.40
13	Fear of teasing by co-workers	(Bridges, 2000; Elwell, 1995)	0.36
14	Lack of rewards for effective reporting of incidents	(Lingard, 2013; Ortega, 2000; Van Der Schaaf and Kanse, 2004)	0.32
15	Production pressure	(Lingard, 2013)	0.28
16	Fear of legal consequences and investigations	((Bridges, 2000; Haslam *et al.*, 2005; Mitropoulos *et al.*, 2005; Umeokafor *et al.*, 2020)	0.28
17	Considering reporting an incident a sign of weakness - Men perspective	(Azaroff *et al.*, 2002; Lingard, 2013)	0.28
18	Insufficient information to complete the required paperwork	(Bridges, 2000; Choudhry and Zahoor, 2016)	0.28
19	Feelings of being misunderstood or undervalued	(O'Leary and Pidgeon, 1995; Van Der Schaaf and Kanse, 2004)	0.28
20	Individuals wishing to not appear incompetent	(Bridges, 2000)	0.24
21	Lack of training and instruction	(Azaroff *et al.*, 2002; Lingard, 2013)	0.20
22	Fear of negative publicity exposure	(Haslam *et al.*, 2005; Mitropoulos *et al.*, 2005)	0.16

23	Fear of breaking the company's "accident-free record"	(Azaroff *et al.*, 2002)	0.16
24	Short-term contract engagement including subcontracting	(Bridges, 2000; Gnoni and Saleh, 2017)	0.16
25	Fear of separation from co-workers	(Lingard, 2013; Umeokafor *et al.*, 2020)	0.12
26	Fear of being assigned to lighter jobs that workers disliked	(Azaroff *et al.*, 2002; Lingard, 2013)	0.12
27	Insurance costs	(Gnoni and Saleh, 2017; Mitropoulos *et al.*, 2005)	0.08
28	Unwarranted surveillance	(Elwell, 1995; Lingard, 2013)	0.22
29	Different cultural, ethnic, and language background	(Bridges, 2000; O'Leary and Pidgeon, 1995)	0.22

2.4. The Technology Acceptance Model (TAM)

Technology acceptance refers to an individual's decision to willingly accept new technology. The intention of users is a critical aspect in the successful adoption and utilization of technology (Kamal *et al.*, 2020). Davis (1986) established this model which has later become one of the most extensively used models for measuring and predicting the likelihood of a system being utilized or denied. TAM, according to Hubona and Geitz (1997), is a measure of attitudes and beliefs that might forecast future behavior. TAM formation is investigated by evaluating the link between two perceptive variables: perceived ease-of-use and perceived usefulness. According to Legris *et al.* (2003), "TAM is utilized to offer a platform for tracing the impact of external variables on internal beliefs, attitudes, and intention", and they also argue that perceived usefulness and perceived ease-of-use are essential elements in system usage.

According to Davis (1989), the end goal of TAM was to describe the drivers of technology adoption in a way that is generic, suitable in describing user behavior across a variety of diverse computing systems, while remaining both theoretically justified and parsimonious. In developing TAM, perceived usefulness is defined by Davis as a "prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context". Perceived ease-of-use is also defined by Davis as "the degree to which the prospective user expects the targets system to be free of effort". It can be narrated as the extent of a user's beliefs about using technology or a system that does not need mental effort. As a result, both of these measures are utilized to assist organizations in better understanding technology acceptances and forecasting user acceptability behavior in information systems. The Theory of Reasoned Action (TRA) (see **Figure 2.2** for reference), a theoretical model of human behavior proposed by Fishbein and Ajzen (1975), served as the foundation for adopting the TAM.

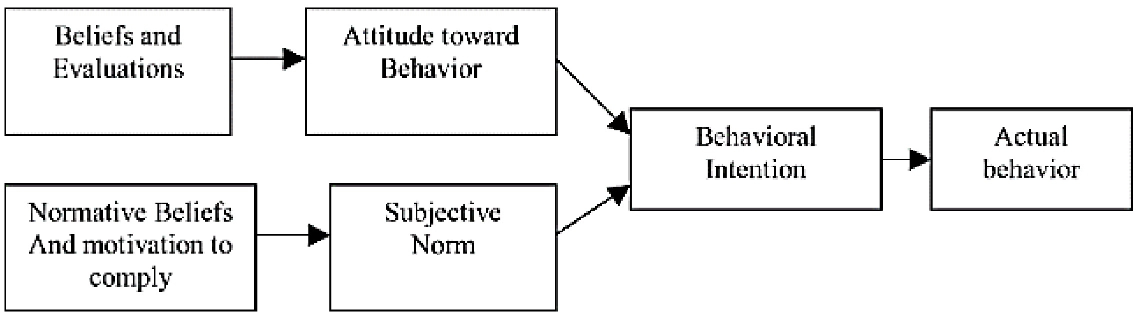

Figure 2.2: Theory of Reasoned Action (TRA)(Ajzen and Fishbein, 1975).

Davis proposed that the goal of TRA was to investigate intentions, beliefs, attitudes, influences, and behaviors, whereas TAM used PEOU and PU to investigate intent to use and actual usage of the system. In the theoretical model of TAM, actual usage is directly tied to behavioral intention, whereas behavioral intention is dependent on user attitudes and PU about employing the system as shown in **Figure 2.3**.

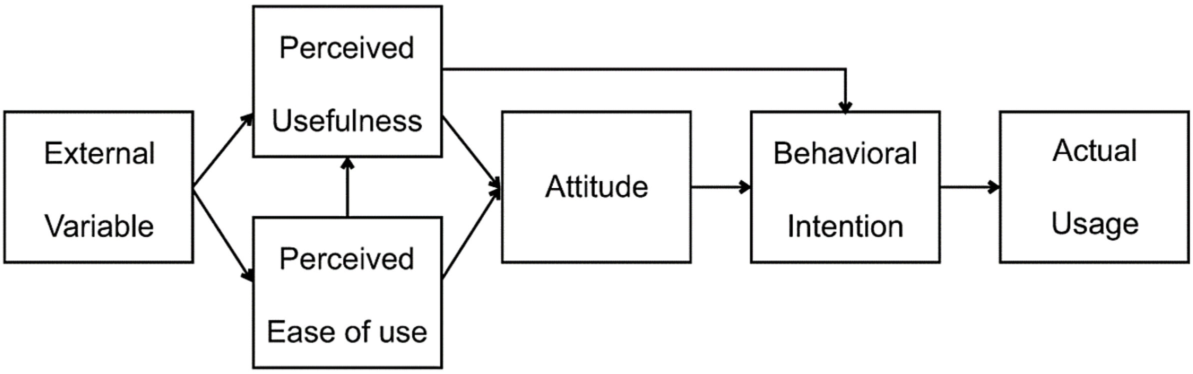

Figure 2.3: Original TAM model (Davis, 1989).

Nevertheless, several researchers have looked into PEOU and found that it may affect actual system usage as well as a direct impact on PU (Davis, 1989). TAM's success stems from its simplicity and IT-specificity; it has a solid empirical base including well-researched and established psychometric scales, and it has garnered substantial backing considering its significant explanatory power (Yousafzai *et al.*, 2007).

2.5. Modified Technology Acceptance Model

The original TAM model is comprised of behavioral intention to use, perceived ease-of-use, perceived usefulness, attitude toward usage, and actual system use. Although the advantages of using TAM cannot be ignored, however, several research studies have voiced reservations about using TAM with its original constructs and encouraged the inclusion of external variables to describe user intentions towards information technologies. Several changes to TAM have been made over the years to address wide characteristics of user acceptance and adoption of IS solutions in enterprises (Mercurio and Hernandez, 2020). TAM theory had multiple revisions. TAM-2, for example, was the extended result developed by Venkatesh and Davis (2000), who introduced drivers of perceived usefulness and usage intention constructs to the original TAM while eliminating attitude variables shown in **Figure 2.4**. Social influence processes i.e., and image and subjective norm cognitive processes i.e., result demonstrability, perceived ease-of-use, and job relevance were added to TAM (Venkatesh & Davis, 2000). The social factor of subjective norm adapted from TRA/TPB was considered a key component of TAM-2 suggesting that important social referents could drive a certain behavior in an individual even if he were not favoring it in the first place.

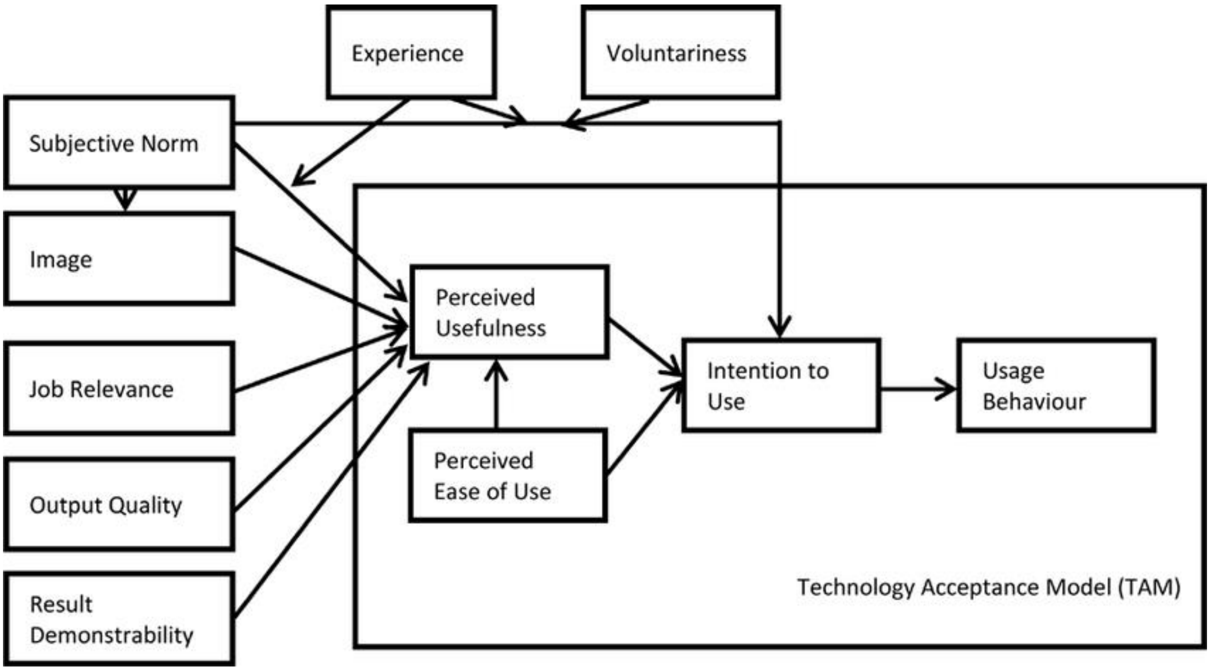

Figure 2.4: The Extension of The Technology Acceptance Model (TAM-2)(Venkatesh and Davis, 2000).

Further, TAM-3 was created by Venkatesh and Bala (2008), who focused on factors linked to perceived ease-of-use and perceived usefulness. It was proposed that factors of perceived usefulness would be unique and would yield no effect on perceived ease-of-use and vice versa. Furthermore, TAM-3 hypothesized new connections in which "experience" acted as a moderator and would influence the interconnection between perceived ease-of-use and each of computer anxiety, perceived usefulness, and behavioral intention (Venkatesh & Bala, 2008). TAM-3 is provided in **Figure 2.5** showing its various constructs.

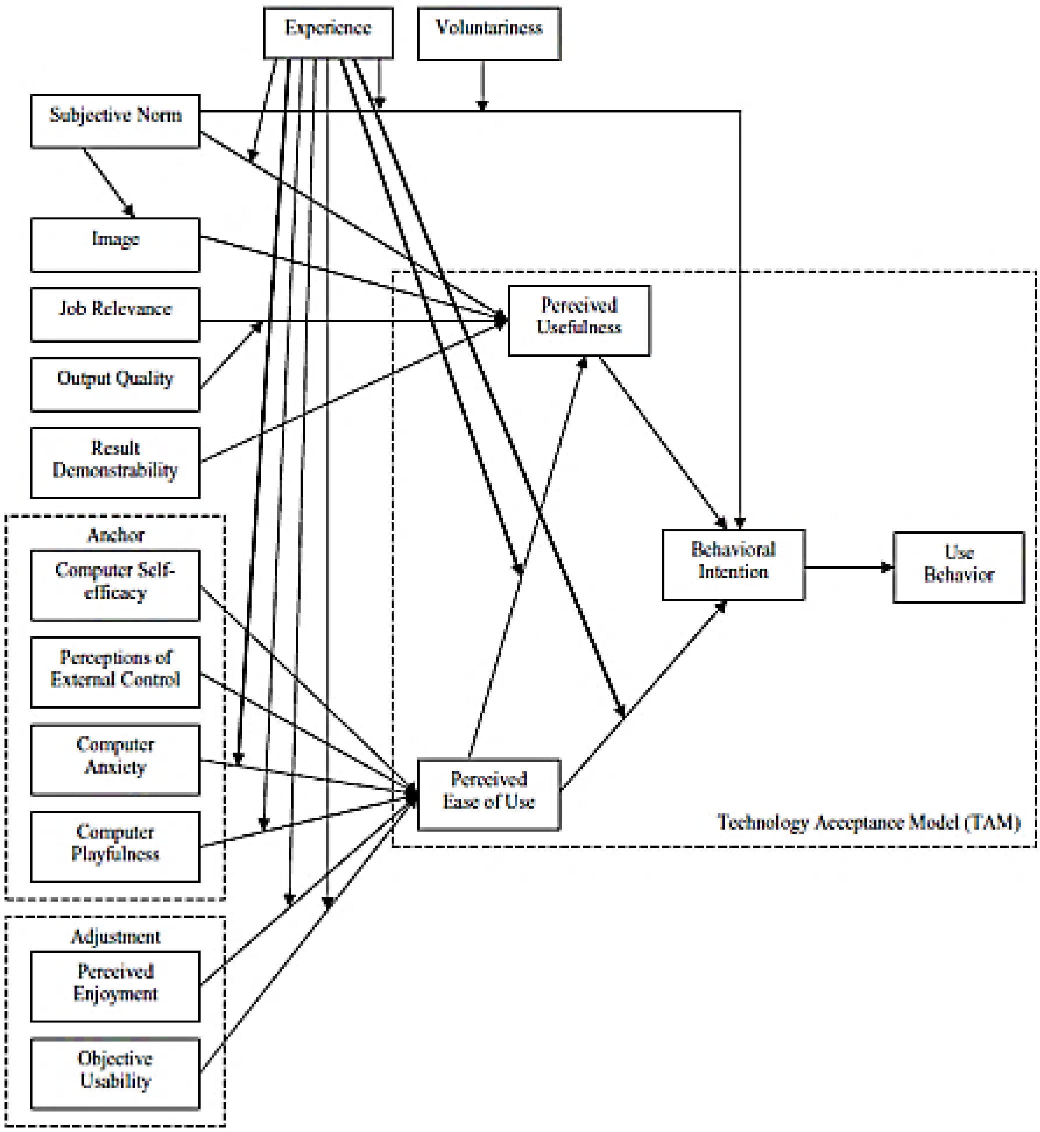

Figure 2.5: Technology Acceptance Model (TAM-3)(Venkatesh and Bala, 2008).

In the subsequent extensions of TAM, the variable attitude was removed deliberately. The reason behind the elimination of this construct was to better understand the direct impact of perceived usefulness on actual system use of the new technologies. Simultaneously, by deleting the attitude variable, any inexplicable direct influence detected from system attributes to the attitude variable was avoided. Moreover, the fundamental positions of two belief constructs, perceived ease-of-use, and perceived usefulness, may be identified as fixed in all the extensions. As a result, it is reasonable to argue that the structure and main assumptions of these extended models are the same as those of the originally proposed TAM (Marangunić and Granić, 2015).

Respondents' usage intentions cannot be adequately explained by a few indicators in a specific user situation. According to researchers, the intertwining effect of numerous social elements such as facilitating conditions and social influence (Kamal *et al.*, 2020), personal attributes such as technology self-efficacy (Purnomo and Lee, 2013), and system characteristics such as trust (Wu *et al.*, 2008) can greatly alter user behavior towards the acceptance of new technology. Numerous studies have utilized the TAM to predict the intentions of end-users with the inclusion of external variables that better suited the system characteristics. For instance, Ifinedo (2016) incorporated the demographic and individual characteristics in TAM to investigate nurses' acceptance of Information systems. Sukendro *et al.* (2020) Included FC as an external variable and fused it in TAM to check the student's interest in e-learning during the pandemic. Further, Akbari *et al.* (2020) along with the TAM variables, also tested the variables of trust and concentration to predict the acceptance of 5G. Moreover, the actual and future use of statistical software was analyzed in Slovenia among the student community using TAM in combination with five external variables (Brezavšček *et al.*, 2017).

2.6. TAM in the Field of Construction

In the domain of the construction industry, overall only a limited number of studies have been published that focused on the utility of TAM to comprehend the user's intentions towards the variety of information systems being adopted in the industry (e.g. Elshafey *et al.*, 2020; Park *et al.*, 2012; Sepasgozaar *et al.*, 2017; Wong *et al.*, 2021). However, the behaviors around building information modeling (BIM) use in the construction industry has been studied by many researchers using this model. Hong and Yu (2018) outlined the various factor that affect the adoption of BIM tools and described the anticipated implications when the relationship between factors is presumed and validated using TAM. In another study, Lee *et al.* (2015) proposed a BIM acceptance model and termed it as BAM which sought to identify factors influencing BIM acceptability from both an organizational and individual standpoint. Furthermore, the model may be used to assess an individual's and an organization's capability for BIM acceptance. According to the study's findings, users in the United States have a greater level of BIM adoption compared to users in Korea, and the two sides share different mechanisms for BIM adoption. In line with these studies, Son *et al.* (2015) offer a framework for enhancing knowledge of user acceptance thus maximizing the likelihood of successful BIM adoption. To study BIM acceptance in Korea, Park *et al.* (2019) researched the determinants of BIM adoption and analyzes compatibility, cost, system control, display quality, and organizational support as potential motivators for using BIM-based tools.

Furthermore, a few other studies also used TAM to study several other technologies. Leue *et al.* (2014) established an AR-TAM model and defined new external variables that affect perceived usefulness and perceived ease-of-use in augmented reality (AR), such as perceived interest, perceived pleasure, information quality, costs, and personal innovativeness. Elshafey *et al.* (2020) developed an extended TAM to predict the acceptance of BIM and AR applications in the construction industry. Wong e*t al.* (2021) investigated the factors influencing the usage of PPE among construction workers and discovered that safety management practices were important in shaping attitudes about the use of PPEs. Park *et al.* (2012) investigated the determining factors of construction professionals' reception of web-based training. Sepasgozaar et al. (2017) established the Scanner Technology Acceptance Model (STAM) for the acquiescence of 3D scanners in the construction industry, which uses two primary criteria: 'ease of use' and 'usefulness'. Further, Chen *et al.* (2020) studied the internet of things (IoT), Liu *et al.* (2018) examined smart construction systems, Park and Park (2020) considered information technology (IT), Sorce and Issa (2021) researched the information and communication technology (ICT) and Okpala *et al.* (2021) analyzed the wearable sensing devices (WBS) in the domain of construction. Nevertheless, the adoption behavior of an electronic incident reporting system and factors contributing to its usage in the construction industry have not yet been realized despite the fact that many researchers have stressed the usage of an E-IRS in the construction industry.

Chapter 3

RESEARCH METHODOLOGY

This chapter will aid in understanding the methods used to meet the research objectives outlined in Chapter 1. Initially, a thorough literature analysis was conducted to identify the barriers to successful reporting of construction safety violations. Based on the literature analysis, a questionnaire survey was completed by health and safety experts for the assessment and ranking of identified barriers. Multiple techniques will be used to carry out this research as per the requirements of said objectives. In this chapter complete methodology is discussed about data collection and its analysis.

3.1. Research Design

The term "research design" refers to a methodical approach to conducting any research by the integration of multiple techniques. The research was divided into four stages. The research topic was recognized and research objectives were developed during the first phase. In the second phase, a comprehensive literature analysis was performed to identify the barriers related to the reporting of safety incidents. After literature analysis, a preliminary survey was performed to include input from field professionals', to shortlist and rank the identified barriers.

In the third phase, research hypotheses were postulated based on the modified TAM and a model was then proposed. To validate the proposed model, a questionnaire was developed and floated in the construction industry of developing countries to look into the behavioral intention towards the use of E-IRS. The survey results were then analyzed using various statistical methods. In the fourth phase, some practical implications for effective incident reporting were developed based on the responses that consisted of the organizational and the individual guidelines for the use of E-IRS (see **Figure 3.1** for details).

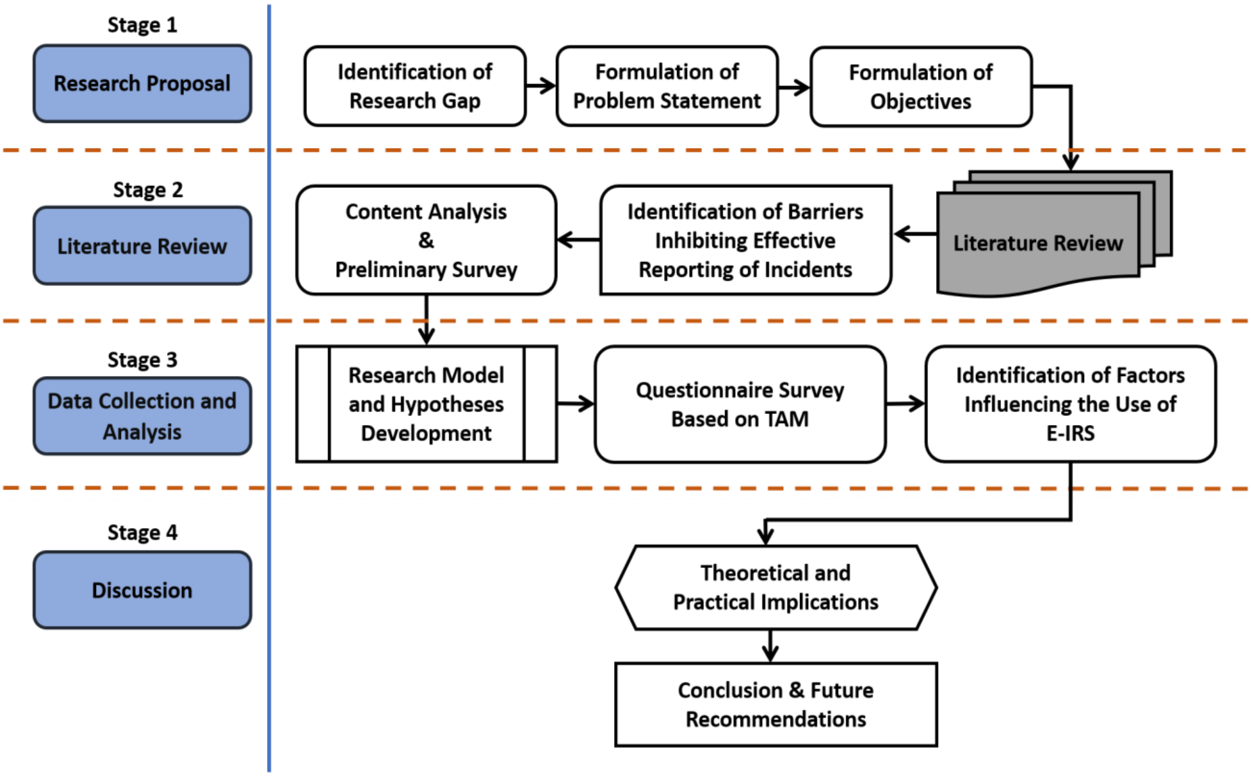

Figure 3.1: Research Roadmap.

The study gap and problem statement were used to identify the research problem, which led to the formation of research objectives. The extensive study of literature was carried out from research articles, conference papers, and relevant books to establish the research gap. Considering all these trends and research gaps, the research objectives of the study were formulated and finalized.

3.2. Barriers Identification

It was identified from the previous literature studies that several barriers obstruct the timely and accurate reporting of safety incidents which compromises the health and safety at construction sites. Barriers that inhibit effective reporting of incidents were identified with a twofold approach. Firstly, the barriers to effective incident reporting were identified from critically examining the literature and a total of 29 barriers were identified (see section 2.3.5 for details).

3.2.1. Preliminary Survey

After literature analysis, a preliminary survey was performed to include input from field professionals' as well, to shortlist and rank identified barriers. The field professionals were mainly associated with the health and safety domain as shown in **Table 2** having extensive work experience in national and international projects. Around 33% of the participants were safety engineers, 27% safety managers, safety professionals, and safety officers were 17% each while the remaining 6% were safety educators.

Table 2: Professional Role of Preliminary Survey Respondents

Current Position	No. of Respondents	Percentage (%)
Safety Manager	8	27
Safety Professional	5	17
Safety Engineer	10	33
Safety Educator	2	6
Safety Officer	5	17

A preliminary questionnaire survey was first drafted and then circulated to experts. A total of 30 questionnaire responses were received for this purpose as acknowledged by Chan *et al.* (2018), a minimum sample size of 30 or greater is necessary to satisfy the central limit theorem. A survey was administered through Google Forms and consisted of two sections; section 1 inquired respondent's demographic and organizational information while section 2 required the respondents to rate the impact of barriers that were earlier identified on a five-point Likert scale where, “1=Low, 2=Moderately Low, 3=Medium, 4=Moderately High, and 5=High”. The majority of the respondents (40%) of the preliminary survey have experience of 1-5 years. The specifics of respondents' work experience in the domain of health and safety are shown in **Figure 3.2**.

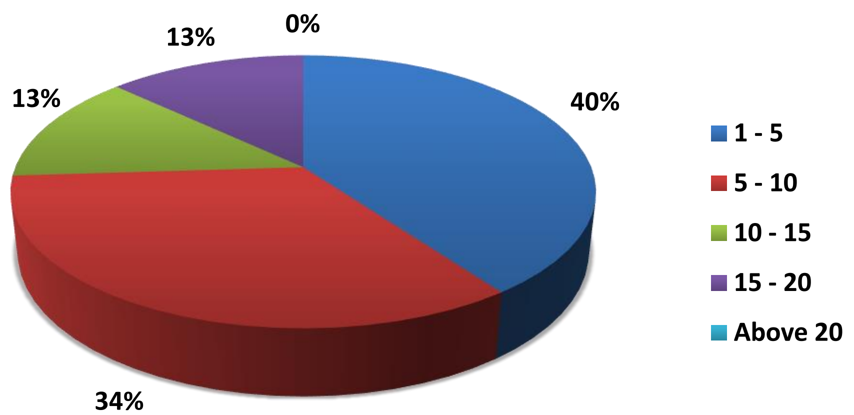

Figure 3.2: Professional Experience of Preliminary Survey Respondents.

3.2.2. Shortlisted Barriers

To check the internal consistency of the responses obtained through the questionnaire survey the Cronbach’s coefficient alpha method is adopted. The recommended threshold value of Cronbach's alpha must be greater than 0.7 to be considered acceptable (Cronbach, 1951). The collected data had a value of 0.91 which indicated the data to be reliable and consistent. Based on the preliminary survey, the field scores were also calculated and then normalized. Different weighting combinations i.e., 70/30, 60/40, and 50/50 to field experts and literature respectively were performed. One-way ANOVA was carried out using SPSS to statically test the weighting ratios. The *p*-value of 1 suggested that there is no substantial difference between various decision weight combinations. Hence, based on the discussion with academic experts, a 60/40 (60% = Field, 40% =

Literature) weighting ratio was adopted to select 11 major barriers to incident reporting. The barriers were selected given due significance to the simple majority principle having above 50% cumulative impact. **Table 3** shows the details of shortlisted barriers to incident reporting including their normalized score, cumulative score, and relative ranking.

Table 3: Shortlisted Barriers to Incident Reporting

Barriers to Incident Reporting	Normalized Score	Cumulative Normalized Score	Ranking
Acceptance of some hazards as part of routine work	0.056453855	0.056453855	1
Job insecurity and fear of job loss	0.054651594	0.111105448	2
Reporting Procedure is not appropriate and is time-consuming	0.053169014	0.164274463	3
Fear of disciplinary action	0.051686434	0.215960897	4
Lack of management commitment to report incidents	0.050523536	0.266484433	5
Confusion regarding what is reportable	0.047238695	0.313723128	6
Financial incentives to achieve zero-accident targets	0.047238695	0.360961824	7
Lack of feedback on how information reported has been used	0.044273536	0.40523536	8
Lack of knowledge about reporting requirements	0.044273536	0.449508895	9
Fear of damaging future employment or career progression opportunities	0.041308377	0.490817272	10
Lack of trust in the anonymity of the IRS	0.036540956	0.527358228	11

3.3. Electronic Incident Reporting System (E-IRS)

Many researchers have employed the E-IRS's in response to barriers that prevent effective incident reporting (Al-Rayes *et al.*, 2020; Martowirono *et al.*, 2012; Qureshi *et al.*, 2021; Wu *et al.*, 2008). The key driver behind this development was the goal to replace paper-based incident reporting, thereby catering to the privacy concerns of reporters and avoiding the common delays caused by manual data entry (Al-Rayes *et al.*, 2020). Previous research showed that implementing E-IRS enhanced events reported and developed confidence among the reporters to use the reporting system as it accommodates anonymity and intact the confidentiality of the reporters (Wu *et al.*, 2008). Some of the benefits of Electronic Incident Reporting System (E-IRS) includes:

1. Better legibility of reports
2. Shorter data entry time
3. Active notification process
4. Anonymity and confidentiality
5. Availability of discussion forum
6. Immediate information sharing
7. Viewing of report
8. Real-time mitigation
9. Improved tracking

Owing to the benefits of E-IRS, this study recommends the use of E-IRS as a mitigation strategy for the identified barriers that inhibit effective incident reporting in the construction industry. However, before using the technology-based solution, Winsvold Prang and Jelsness-Jørgensen, (2014) pointed that inadequate knowledge of how to utilize the system and lack of electronic confidence could be a possible deterrent that could affect the successful implementation and utilization of the system. Therefore, before implementing such a solution it is appropriate to understand that how respondents will respond to the emergence of the new system. Chapter 2 of this study goes into detail on the technology acceptance model (TAM) and the way it aids in understanding user behavioral intention.

Chapter 4

THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

This chapter aims to build the theoretical foundation and study hypotheses to examine the factors that influence E-IRS acceptance, which will be tested later in this study. Details about the TAM variables and the selected external variables are presented along with the postulated hypotheses. In the end, a model is presented based on the established hypotheses.

4.1. Variables

An overview of TAM and external variables that were presented in the study and used for analysis are given below:

4.1.1. TAM variables

Behavioral Intention (IN): The importance of IN have been explained in various models and theories, such as Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1975); the Technology Acceptance Model (TAM) (Davis, 1989); TAM-2 (Venkatesh and Davis, 2000); TAM-3 (Venkatesh and Bala, 2008); and Theory of Planned Behavior (TPB);. Behavioral intention (IN) is an end user's interest in employing a specific system or technology for future work (Al-Rayes *et al.*, 2020). In reference to this study, IN refers to an employee's intended plan to use an E-IRS and its acceptance in the construction industry. This variable is a dependent variable and needs to be assessed through this study.

The measurements used to predict the participants' IN are borrowed from Wu *et al.* (2008) and Venkatesh and Davis (2000). To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

Perceived Usefulness (PU): The original TAM considers perceived utility to be a critical component (Davis, 1989). The degree to which end users believe that the use of a particular technology will assist them in executing their job efficiently is referred to as perceived usefulness (Al-Rayes *et al.*, 2020). In the context of this research, PU describes the extent to which construction workers believe that adopting the E-IRS will help to improve health and safety performance on the job. PU is assumed to be a direct antecedent of IN in previous technology acceptance models. In line with past research on technological acceptance, this research hypothesizes that employees' PU of the system has a substantial effect on IN to use E-IRS. To inspect the impact of PU on IN, the subsequent hypothesis is anticipated;

H1: Perceived usefulness (PU) has a significant positive effect on behavioral intention (IN) to use the E-IRS.

The measurements used to predict the participants' IN are borrowed from Wu *et al.* (2008) and Venkatesh and Davis (2000). To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

Perceived Ease-of-use (PEOU): Another major construct in the original TAM besides perceived usefulness (PU) was perceived ease-of-use (PEOU). The degree to which a user believes the new technology is simple to use is referred to as PEOU (Al-Rayes *et al.*, 2020). In the case of this study, PEOU is the extent to which an employee in the construction industry considers that technology will require little mental and physical effort in using E-IRS. Therefore, It is important to mention that the employees are more likely to use the system if they perceive that the system is simple to use. The original TAM model indicated that PEOU had a considerable effect on PU. Further in line with the literature concerning technology acceptance, this research assumes that employees' PEOU about the system has a significant effect on IN to use E-IRS and PU of the system. Therefore, the hypotheses listed below are offered to investigate the impact of PEOU on IN and PU;

H2: Perceived ease-of-use (PEOU) has a significant positive effect on behavioral intention (IN) to use E-IRS.

H3: Perceived ease-of-use (PEOU) has a significant positive effect on perceived usefulness (PU).

The measurements used to predict the participants' IN are borrowed from Wu *et al.* (2008) and Venkatesh and Davis (2000). To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

4.1.2. External Variables

The following assumptions help in the selection of the external variables for the model:

- The number of exogenous factors should be kept to a minimum in order to avoid model complexity. Typically, three to five external variables are comprised in TAM applications (Brezavšček *et al.*, 2017).
- The external factors with theoretical underpinnings in the literature are preferable (Li *et al.*, 2008). Further, Jimenez *et al.* (2021) estimated the frequency of each determinant after individuating the variables contained in the prior selected research based on TAM applications (see **Table 4** for reference).

Table 4: Most frequently used external variables in TAM applications

External Variables	Included in the Proposed Model of Studies
Anxiety	7
Content quality	11
Experience	7
Facilitating conditions	10
Individual innovativeness	8
Perceived enjoyment	8
Self-efficacy	30
Service/System quality	7
Social norm	24

Source: (Jimenez *et al.*, 2021)

- While deciding the external variables for our E-IRS acceptance model we first considered the empirical investigations of Wu *et al.* (2008), whose key determinants were trust, social influence, and management support for testing the acceptance of an adverse event reporting system in a healthcare setting. Since trust appears as a major barrier indicated in the shortlisted barriers to incident reporting (see **Table 3**), we expected that it would be crucial for our model.
- The most widely employed external factors in TAM applications were self-efficacy, social influence/social norm, and Facilitating Conditions (Jimenez *et al.*, 2021; Yousafzai *et al.*, 2007). Hence, we have included them in our model as external variables for a thorough understanding of their impact from the perspective of the construction industry.

Details about the selected variables have been presented in the sub-sections below:

Trust (T): Trust is defined as "the extent to which one is willing to ascribe good intentions too, and have confidence in, the words and actions of other people (or systems)" (Wu *et al.*, 2008). Trust has always been viewed as a crucial factor in determining whether or not new technology will be accepted. Numerous researches have validated the incorporation of the "trust" variable in TAM theoretical models for a better explanation of system adoption and integration (Gefen and Straub, 2000; Jimenez *et al.*, 2021; Kamal *et al.*, 2020). Implementing a successful E-IRS would necessitate a culture shift in the construction industry, as well as encourage open discussion of mistakes and learning from failures. Lack of trust and negative publicity are significant impediments that may discourage incident notifiers from using a reporting system (Wu *et al.*, 2008). The following hypotheses are offered to study the impact of T;

H4: Trust (T) has a significant positive effect on behavioral intention (IN) to use E-IRS.

H5: Trust (T) has a significant positive effect on perceived usefulness (PU).

The measurements used to predict the participants' IN are adopted from Wu *et al.* (2008). To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

Technological Self-efficacy (TSA): Self-efficacy has been used as a common external factor of TAM (Jimenez *et al.*, 2021). Technological Self-efficacy (TSA) is defined as "User's confidence in their capabilities to perform a task, achieve a specific goal, or produce the desired outcomes by properly using an innovative system or device" (Kamal *et al.*, 2020). One of the barriers to incident reporting is the employee's perception that reporting procedure is not appropriate. Therefore, those employees who would have difficulty in understanding and using the system would not readily adopt E-IRS. In short, if the employees are not considering the system easy to use, they are not finding the system useful. Therefore, to investigate the impact of TSA on PEOU and PU, the subsequent hypotheses are suggested;

H6: Technological self-efficacy (TSA) has a significant positive effect on perceived usefulness (PU).

H7: Technological self-efficacy (TSA) has a significant positive effect on perceived ease-of-use (PEOU).

The measurements used to predict the participants' IN are adopted from Chao (2019). To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

Facilitating Conditions (FC): It is defined "as the existence of adequate organizational and technical infrastructure for a user's support to adopt a new technology" (Kamal *et al.*, 2020). The availability of resources necessary for the effective use of the E-IRS including the provision of electricity, internet, and technical support would enhance the ease with which reporting could be done. In previous studies, it has been concluded that facilitating conditions positively affect the attitude of the user towards the system (Bryson and Atwal, 2013; Kamal *et al.*, 2020; Sepasgozaar *et al.*, 2017; Venkatesh and Davis, 2000). It has also been identified that FC has the strongest positive effect on PEOU and PU (Bryson and Atwal, 2013; Sukendro *et al.*, 2020). Therefore, this research intends to check the influence of FC by considering the following hypotheses;

H8: Facilitating conditions (FC) have a significant positive effect on perceived usefulness (PU).

H9: Facilitating conditions (FC) have a significant positive effect on perceived ease-of-use (PEOU).

The measurements used to predict the participants' IN are adopted from Venkatesh *et al.* 2012. To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

Social Influence (SI): It is defined as "the extent to which the ideas coming from others may foster or discourage the use of technology" (Jimenez *et al.*, 2021). The social influence could be the extent to which an employee feels environmental and peer pressure to practice E-IRS. It is a common belief that motivation towards a particular situation may get influenced by people who are valued. In the case of the construction industry, the behavior towards the E-IRS could be influenced if higher authorities give stress towards the use of the system or make its usage mandatory. Past research has shown that SI is positively related to PU (Elshafey *et al.*, 2020; Park *et al.*, 2012; Rezaei *et al.*, 2020). Moreover, social influence also significantly affects trust in the system (Wu *et al.*, 2008). Reporting will take place only if employees feel legally and professionally safe in doing so, and if it is viewed as a culturally acceptable action within the community (Kamal *et al.*, 2020). To study the impact of SI, the subsequent hypotheses are anticipated;

H10: Social influence (SI) has a significant positive effect on perceived usefulness (PU).

H11: Social influence (SI) has a significant positive effect on trust (T).

The measurements used to predict the participants' IN are adopted from Venkatesh *et al.* (2012) and Venkatesh and Davis (2000). To capture the participants' behavioral intentions, three separate statements were employed as shown in **Table 6**. The variable's value is the participant's average score across all three assertions.

A total of 11 hypotheses have been established in the study as shown in **Table 5** based on the aforementioned review.

Table 5: Hypotheses for the Study

Construct	Count	Hypothesis
Perceived usefulness	H1	Perceived usefulness has a significant positive effect on behavioral intention to use the E-IRS
Perceived ease-of-use	H2	Perceived ease-of-use has a significant positive effect on behavioral intention to use E-IRS
	H3	Perceived ease-of-use has a significant positive effect on perceived usefulness
Trust	H4	Trust has a significant positive effect on behavioral intention to use E-IRS
	H5	Trust has a significant positive effect on perceived usefulness
Technological Self-efficacy	H6	Technological self-efficacy has a significant positive effect on perceived usefulness
	H7	Technological self-efficacy has a significant positive effect on perceived ease-of-use
Facilitating conditions	H8	Facilitating conditions has a significant positive effect on perceived usefulness
	H9	Facilitating conditions has a significant positive effect on perceived ease-of-use
Social influence	H10	Social influence has a significant positive effect on the perceived usefulness
	H11	Social influence has a significant positive effect on trust

4.2.Proposed Model

A conceptual model is an illustration that represents the exogenous and endogenous constructs employed in the research, as well as the links among them and the hypotheses that will be investigated (Hair *et al.*, 2016). The proposed model of this research is shown in **Figure 4.1** which is divided into two components. The first part consists of TAM variables: perceived ease-of-use, perceived usefulness, and behavioral intention to use. The second part consists of external variables: trust, facilitating conditions, technological self-efficacy, and social influence.

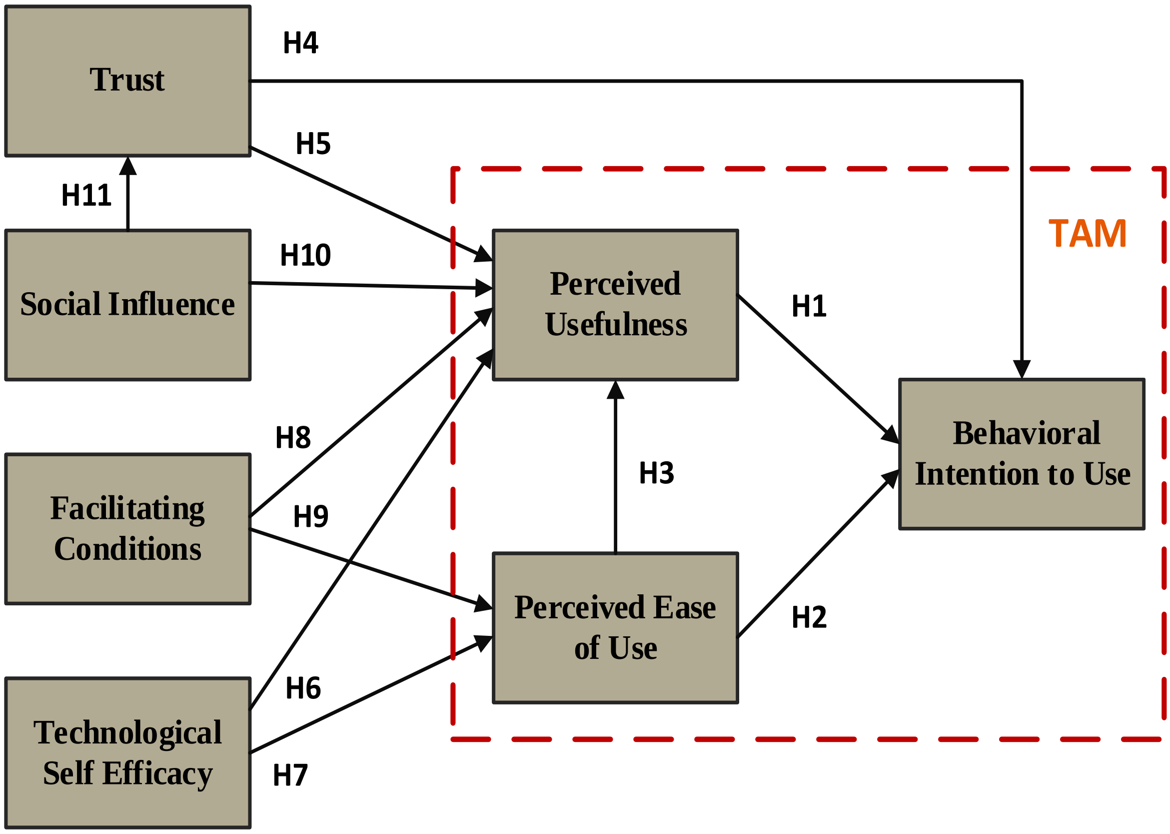

Figure 4.1: The Proposed Model.

The proposed model is tested in the later chapters of this dissections. Details about the methods adopted to test the hypotheses along with the tools have been discussed to give an explanation of the study techniques.

Chapter 5

STUDY DESIGN AND ANALYSIS

5.1. Questionnaire Design

To test the hypotheses that have been earlier postulated in **Table 5**, a questionnaire was designed. To assure content validity, the study's questions were adapted from earlier TAM investigations, with only minor phrasing adjustments to meet the context of E-IRS. Details about the variables and the corresponding measurements used in the study have been discussed in detail in section 4.1. the final questionnaire design involved three sections. The first section expressed admiration for the participants' willingness to participate in the exercise, and the study was briefly detailed. The respondents were assured that their personal information would be kept strictest confidence and individual names or job descriptions will not be used in the study.

In the second section, demographic-related questions regarding participants' gender, age, work sector, education level, work experience, and country of work were asked. In the third section, questions related to variables presented in the model were asked. The participants were given 18 statements to measure the influence of the model's various constructs. Details of the statements and corresponding references are given in **Table 6**. A five-point Likert-type scale anchored on "1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree" was used.

Table 6: Overview of variables and measurements

Constructs	Items	Measurements	References
Perceived ease-of-use (PEOU)	PEOU1	Learning the E-IRS would be easy	(Venkatesh and Davis, 2000; Wu *et al.*, 2008)
	PEOU2	Operating the E-IRS would not be hard	
	PEOU3	It would be easy for me to become skillful at using the E-IRS	
Perceived Usefulness (PU)	PU1	Using the E-IRS would offer me the chance to learn from mistakes	(Venkatesh and Davis, 2000; Wu *et al.*, 2008)
	PU2	Using the E-IRS would improve safety performance	
	PU3	Using the E-IRS would make reporting incidents easy and quick	
Trust (T)	T1	I feel assured that legal and technological structures adequately protect me from problems on the reporting system	(Wu *et al.*, 2008)
	T2	I believe that E-IRS would be trustworthy to use	
Social Influence (SI)	SI1	People who are important to me would prefer if I use E-IRS	(Venkatesh *et al.*, 2012; Venkatesh and Davis, 2000)
	SI2	People who significantly influence my behavior would prefer if I use E-IRS	
Facilitating conditions (FC)	FC1	I would be able to have all the necessary resources for using the E-IRS	(Venkatesh *et al.*, 2012)
	FC2	I can get help from others when I have difficulties using the E-IRS	
Technological Self-efficacy (TSE)	TSE1	I am confident of using the E-IRS even if I have never used such a system before	(Chao, 2019)
	TSE2	I am confident of using the E-IRS even if there is no one around to show me how to do it	
	TSE3	I am confident of using E-IRS even if I have only the system manuals for reference	
Behavioral Intention to use (IN)	IN1	When I encounter an accident due to my mistake, I would report	(Venkatesh and Davis, 2000; Wu *et al.*, 2008)
	IN2	When I encounter an accident due to other's mistake, I would report	
	IN3	I intend to use the E-IRS as often as needed	

5.2. Data Collection

For collecting the survey data, an online questionnaire was developed through Google Forms. An online questionnaire survey is somehow the easiest and fastest way for the collection of primary data, globally. It enables the researcher to reach those respondents who are at a far geographical distance in a shorter period (Duthler, 2006). As the area of study of this research was limited to developing countries, the online questionnaire was only circulated to developing countries of the world as a URL which allowed the respondents to directly access the survey. The questionnaire was floated among individuals across the developing countries through online social and professional community platforms such as Facebook®, LinkedIn®, Email, etc. with prior experience in the construction sector. There was a total of 136 collected responses through the online survey from developing countries.

5.3. Data Screening

When analyzing data with the SEM technique, Hair *et al.* (2017) stated that data screening is an important criterion. The issues including unengaged respondents, missing data, strange response patterns, outliers, and data distribution should preferably be analyzed before applying SEM (Hair *et al.*, 2017). Therefore, the key data issues were first investigated using SPSS version 26 in the following steps;

5.3.1. Missing Data

This problem arises when respondents leave questions unanswered in the survey. Missing data leads to erroneous research findings and potentially causes bias in the results (Binyamin, 2019). The current study has gathered a total of 136 responses using Google Forms. All of the questions in the survey form were made mandatory for the respondents to fill otherwise the survey could not be submitted. Thus, the final response does not have any issue of missing data.

5.3.2. Unengaged Responses

The issue of unengaged responses arises when respondents choose the same option for all or most of the questions in the survey form making a suspicious response pattern (Binyamin, 2019). This is also sometimes referred to as straight-lining (Hair *et al.*, 2017). To detect suspicious response patterns, the standard deviation was estimated for each case. Responses with a standard deviation value of 0 were dropped as it indicates a straight-lining pattern. It was found that six respondents were not completely engaged in the survey and follow a straight-lining pattern (see **Table 7**). Therefore, those six cases were deleted from the final data examination.

Table 7: Unengaged Responses

Case ID	Maximum Value	Minimum Value	Standard Deviation
86	5	5	0.00
87	5	5	0.00
90	5	5	0.00
93	5	5	0.00
94	5	5	0.00
102	5	5	0.00

5.3.3. Outliers

The issue of outlier arises when the respondent chooses unusual values, making the response excessively distinct from other responses (Sekaran and Bougie, 2016). In order to inspect the outliers, Mahalanobis (D^2) distance was calculated using SPSS. As per a rule of thumb for "large samples (N > 80) in multivariate analysis, cases with $D^2/df > 3$ or 4 with $p < .001$ are regarded influential outliers" (Hair *et al.*, 2014). Here, *df* is the sum of independent variables; which is six in the current study. Two cases of outliers were identified (see **Table 8**) and deleted from the responses for final analysis.

Table 8: Outliers

Case ID	**Mahalanobis (D^2)**	**D^2/df**	***p*-Value**
123	24.189	4.032	$p < 0.001$
134	24.867	4.145	$p < 0.001$

5.3.4. Normality

The normality test ensures that the data assumed is suitable for statistical analysis. Non-parametric data may have an impact on the validity and dependability of multivariate data analysis (Hair *et al.*, 2014). PLS-SEM can deal with non-normal data however, it is preferred to confirm that collected data are not excessively non-normal (Hair *et al.*, 2017). Two important variables are proposed for measuring the normality of data distribution: 1) skewness and 2) kurtosis. Skewness is the measure of the symmetry of data distribution, whereas kurtosis measures the height of the data distribution (Field, 2013). Absolute values of kurtosis and skewness up to 2.3 are reported as unobjectionable (Brezavšček *et al.*, 2017; Lei and Lomax, 2005). The normality test results indicated (see **Table 9**) that the values are within the acceptable range, hence data distribution is not a problem for this study.

Table 9: Normality Test Results

Construct	Items	Skewness	Kurtosis
Perceived Usefulness (PU)	PU1	-1.278	0.993
	PU2	-1.153	0.691
	PU3	-1.318	0.791
Perceived ease-of-use (PEOU)	PEOU1	-0.583	-0.137
	PEOU2	-0.793	0.323
	PEOU3	-0.752	0.007
Trust (T)	T1	-0.603	-0.446
	T2	-0.841	0.008
Social Influence (SI)	SI1	-0.598	-0.353
	SI2	-0.695	-0.298
Facilitating conditions (FC)	FC1	-0.583	-0.334
	FC2	-0.914	0.241
Technological Self-efficacy (TSE)	TSE1	-0.487	-0.618
	TSE2	-0.505	-0.417
	TSE3	-0.657	-0.107
Behavioral Intention to use (IN)	IN1	-0.85	-0.414
	IN2	-1.017	0.19
	IN3	-1.113	0.502

After the initial screening of data eight responses were found to have issues of unengaged responses and outliers and therefore removed. Subsequently, a total of 128 responses were found suitable for further analysis.

5.3.5. Descriptive Statistics of the Constructs

The construct's descriptive statistics after the initial screening of data are provided, together with the mean, standard deviation, and minimum and maximum values, as shown in **Table 10**. Respondents were requested to select the answer on a five-point Likert scale that best expressed their level of agreement for each measurement. The mean values of all the study variables ranged from 3.97 (1.03) to 3.61 (0.99), which is an indication that study participants share a favorable opinion towards E-IRS. Moreover, the behavioral intention (M = 3.84, SD = 1.07) of the participants towards the adoption and use of E-IRS indicates that the system has an acceptance in the construction industry.

Table 10: Descriptive Statistics of Constructs

Constructs	Items	Maximum	Minimum	Mean	SD
Perceived usefulness (PU) Mean = 3.97 SD = 1.03	PU1	5	1	3.961	1.128
	PU2	5	1	3.875	1.159
	PU3	5	1	4.062	1.204
Perceived ease-of-use (PEOU) Mean = 3.64 SD = 0.96	PEOU1	5	1	3.594	1.064
	PEOU2	5	1	3.57	1.066
	PEOU3	5	1	3.766	1.072
Trust (T) Mean = 3.80 SD = 1.06	T1	5	1	3.758	1.102
	T2	5	1	3.836	1.123
Social influence (SI) Mean = 3.59 SD = 1.03	SI1	5	1	3.57	1.095
	SI2	5	1	3.617	1.187
Facilitating conditions (FC) Mean = 3.64 SD = 1.00	FC1	5	1	3.516	1.118
	FC2	5	1	3.758	1.123
Technological self-efficacy (TSE) Mean = 3.61 SD = 0.99	TSE1	5	1	3.602	1.148
	TSE2	5	1	3.453	1.131
	TSE3	5	1	3.773	1.017
Behavioral intention to use (IN) Mean = 3.84 SD = 1.07	IN1	5	1	3.75	1.25
	IN2	5	1	3.883	1.196
	IN3	5	1	3.898	1.185

5.4. Profile of Respondents

The online questionnaire survey was submitted by professionals from developing countries. The purpose of the survey (N=128) was to gather responses from individuals working in the construction industry to understand the behavioral intention and influencing factors towards the use of E-IRS. Besides collecting data about model constructs, information about respondents' demographic characteristics were also collected. The information includes full name, gender, education level, country of work, work experience in the construction industry, and work sector. The details of demographic characteristics are shown in **Table 11**.

Table 11: Frequency Distribution of Responses

Variables	Frequency	Percentage (%)
Gender		
Male	109	85.2
Female	19	14.8
Age Group		
20-29	63	49.2
30-39	45	35.2
40-49	14	10.9
50 years and above	6	4.7
Education Level		
Diploma	15	11.7
Bachelors	63	49.2
Masters	42	32.8
Doctorate	8	6.3
Work Experience		
1–5	62	48.4
6–15	46	35.9
16–25	11	8.6
>25	9	7.0
Work sector		
Public	36	28.1
Private	83	64.8
Other	9	7.0

5.4.1. Geographical Distribution

The survey collected a total of 128 responses including 58% national and 42% international responses. As the focus of this study was on developing countries, all the responses were collected accordingly. Responses were received from countries including Pakistan (58%), India (9%), Bangladesh (7%), Saudi Arabia (7%), Malaysia (6%), Jordan (5%), Qatar (5%), and Kuwait (3%) as shown in **Figure 5.1**.

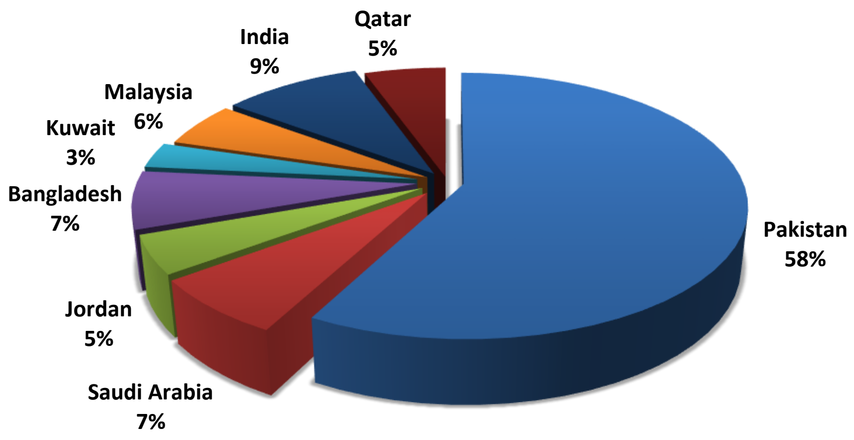

Figure 5.1: Geographical Distribution of Respondents.

5.4.2. Gender

The results of survey data indicated that out of a total of 128 participants 109 were male and only 19 were female as shown in **Figure 5.2**. Less female participation reflects the fact that the construction industry is dominated by men, with less female engagement (Norberg and Johansson, 2021).

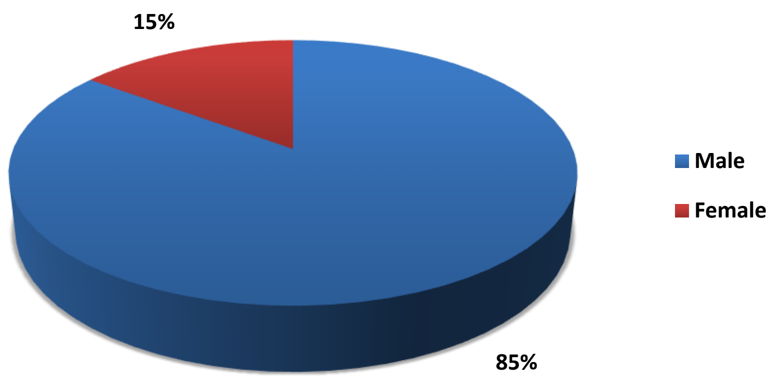

Figure 5.2: Gender groups of Respondents.

5.4.3. Age

The respondent's age distribution is presented in **Figure 5.3**. it had been observed that 63 (49%) participants had an age between 20 to 29 years, 45 (35%) had 30 to 39 years of age, 14 (11%) participants had 40 to 49 years of age while 6 (5%) participants had more than 50 years of age. The age distribution demonstrates the integration of information from all response categories.

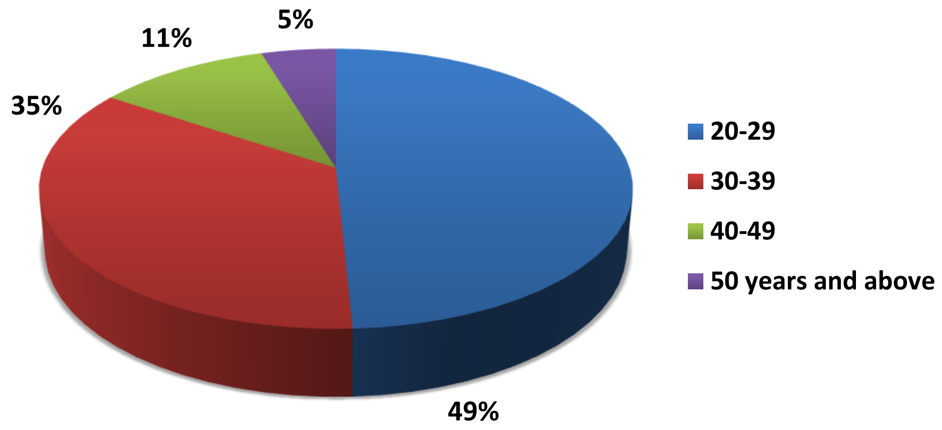

Figure 5.3: Age Distribution of Respondents.

5.4.4. Education Level

In the questionnaire, respondents' education level was examined using an ordinal scale. Results indicated that 15 (12%) of respondents had a diploma, 63 (49%) respondents had bachelors, 42 (335) had master’s degrees and 8 (6%) had a doctorate in the domain of civil engineering (see **Figure 5.4**). The educational distribution of participants is a good blend that incorporates input from everyone.

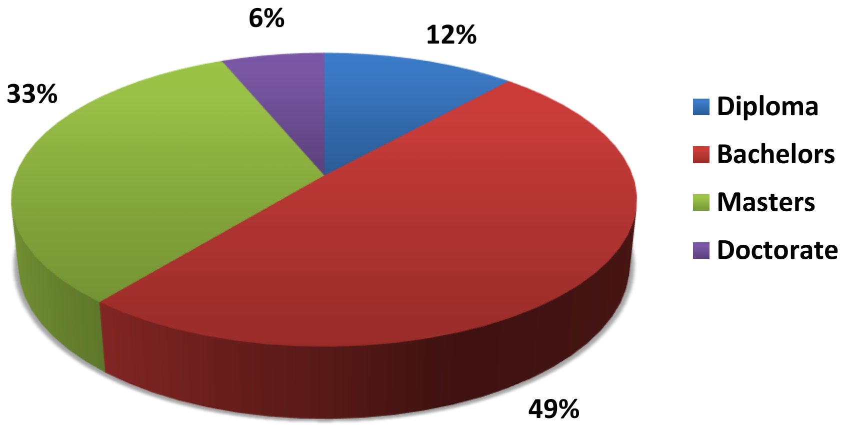

Figure 5.4: Education Level of Respondents.

5.4.5. Work Experience

The respondents had varying years of professional experience. As shown in **Figure 5.5** that 62 (48%) respondents had 1 to 5 years' experience, 46 (36%) respondents had 6 to 15 years' experience, 11 (9%) respondents had 16 to 25 years' experience, and 9 (7%) respondents had 25 years and above experience.

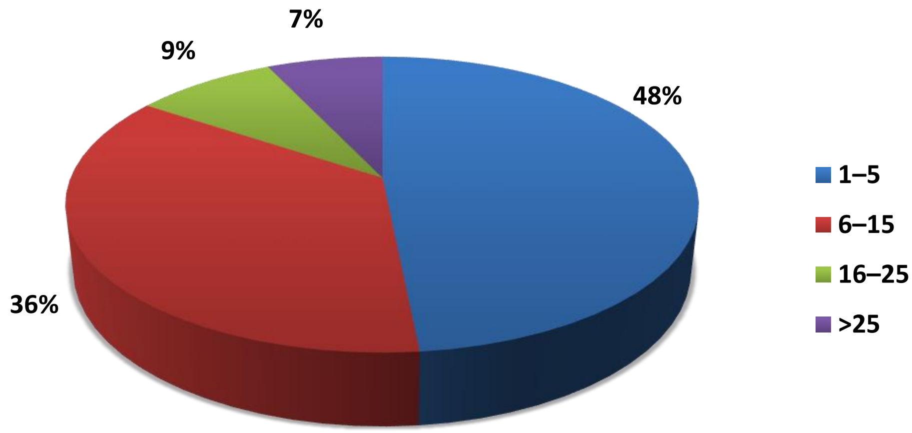

Figure 5.5: Work Experience of Respondents.

5.4.6. Work Sector

The respondent's association with the work sector is presented in **Figure 5.6**. In the questionnaire, the respondents' responses to the work sector were measured using a nominal scale. Around 36 (28%) participants were associated with public sector organizations, 83 (65%) associated with private sector organizations while the remaining 9 (7%) participants were allied with others including; semi-government organizations, non-governmental organizations (NGO), and public-private partnerships (PPP).

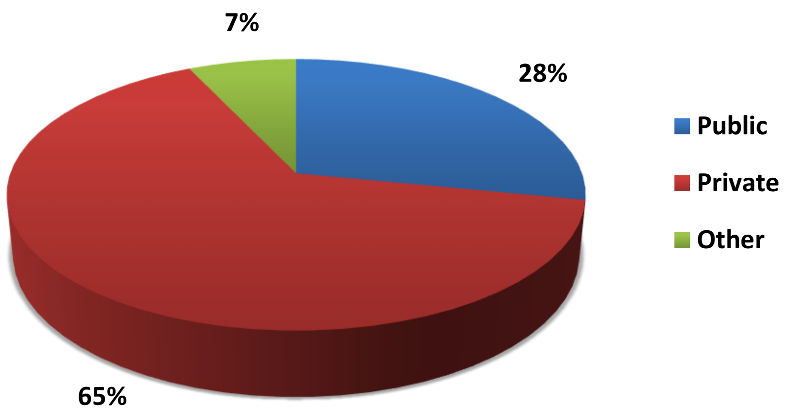

Figure 5.6: Work Sector of Respondents

5.5. Hypotheses Testing

The analysis technique Partial Least Squares-Structural Equation Modeling (PLS-SEM) was used to empirically evaluate the proposed model and validate the hypothesized correlations among factors impacting the adoption of an E-IRS. The majority of the prior researches on TAM have employed this technique in testing hypotheses and to conclude their research models (Alam *et al.*, 2021; Ifinedo, 2015; Kamal *et al.*, 2020; Nikou and Economides, 2017; Salloum *et al.*, 2019; Sukendro *et al.*, 2020). The PLS model consists of structural and measurement models (Binyamin, 2019). The use of PLS-SEM allows for synchronous analysis of structural and measurement models, resulting in more reliable calculations (Barclay *et al.*, 1995). The next section justifies the selection of the PLS-SEM technique adopted for the current study.

5.5.1. Partial Least Squares-Structural Equation Modeling

For more than decades, structural equation modeling (SEM) has been widely utilized in scientific research to evaluate and test causal relations (Fan *et al.*, 2016). SEM is an enhancement of first-generation multivariate analysis techniques like factor analysis, regression, and discriminant analysis, and it permits the synchronous assessment of relationships between study constructs (Hair *et al.*, 2014). The method can be used in one of two ways: PLS-SEM using software packages like PLS-Graph and SmartPLS, or covariance-based structural equation modeling (CB-SEM) using tools like LISREL and AMOS. Although both methods have the same fundamental goal i.e., to investigate the links between constructs. However, they vary significantly when the measurement model is assessed (Hair *et al.*, 2014). PLS-SEM estimates the variance of an unobserved dependent variable, whilst CB-SEM analyzes the variance-covariance matrix. The shortcomings in the CB-SEM approach are considered as the strengths of the PLS-SEM approach, and vice versa. As a result, scholars should view the two approaches as complementing rather than competitive (Hair *et al.*, 2011).

Latent variables, goodness-of-fit, causal models, indirect effects, and complex models cannot be tested using first-generation multivariate analytic methods (Lowry and Gaskin, 2014). Moreover, second-generation approaches can, however, overcome these constraints. It is also important to note that second-generation approaches do not nullify first-generation techniques, but they are better suited for complex modeling (Ong and Puteh, 2017).

When the prime goal of the study is to validate a pre-developed theory, evaluate goodness-of-fit criteria, or compare theories, CB-SEM is more convenient; whereas, PLS-SEM is much more advantageous when the chief goal of the study is to identify critical drivers or expand an existing theory. The PLS-SEM technique is applied to utilize high-quality, user-friendly, and visually appealing software, such as SmartPLS (Henseler and Sarstedt, 2013). SmartPLS is furnished with all the mandatory options necessary for testing the model, such as goodness-of-fit indices, measurement model analysis, path analysis, and multigroup analysis.

5.6. Quantitative Data Analysis

For the analysis of data SmartPLS software, version 3.3.3 was used (Ringle, Christian M., Wende, Sven, & Becker, 2015). To test the model SmartPLS requires data in .csv format. As a result, data were initially exported in .csv format from excel and loaded into the SmartPLS program version 3.3.3 to be analyzed further. After importing data, the model prepared in SmartPLS is shown in **Figure 5.7**. the blue circles indicate the latent constructs of this study, yellow rectangles indicate the measured variables of the latent constructs while the arrows indicate the link among them.

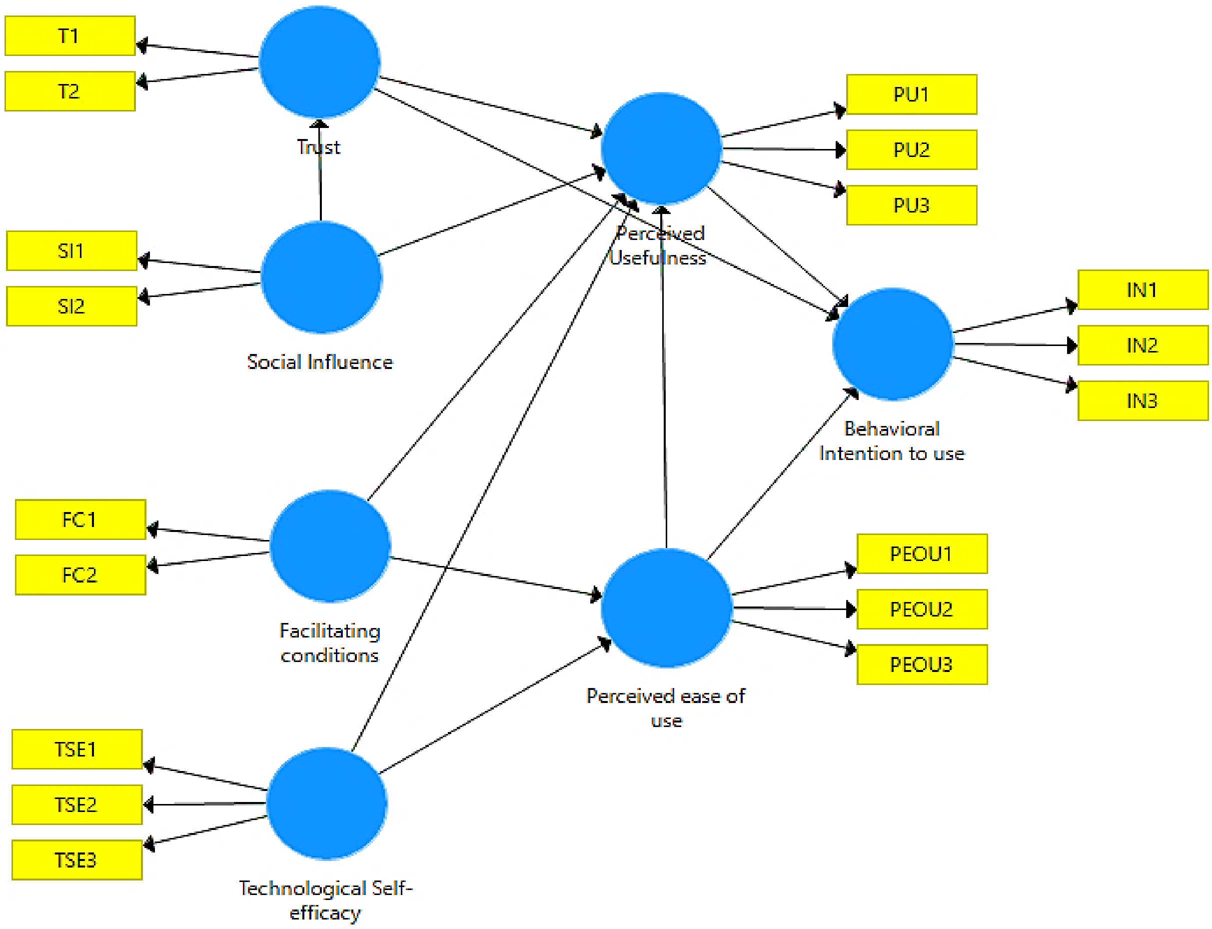

Figure 5.7: Model in SmartPLS version 3.3.3.

5.6.1. Measurement Model Assessment

The measurement model is also denoted as the outer model and it specifies the relationships between the latent variable and their observed variables or measurements (Hair *et al.*, 2011; Henseler *et al.*, 2015). The goal of assessing the measurement model is to see how well the measured variables reflect the latent construct; they are intended to assess (Brezavšček *et al.*, 2017). The current study's evaluation criteria for the measurement model are summarized in **Table 12**. Previous studies that utilized PLS-SEM for model testing and data analysis usually report these criteria when testing and reporting the measurement model which includes; construct reliability, indicator reliability, discriminant validity, and convergent validity (Ifinedo, 2015; Kamal *et al.*, 2020; Nikou and Economides, 2017).

Table 12: Measurement Model's Assessment Criteria

Validity Type	Criteria	Guidelines	References
Indicator reliability	Item Loadings	Item Loading ≥ 0.7	(Chin, 1998)
Construct reliability	Cronbach's alpha (CRA)	CRA ≥ 0.7	(Hair *et al.*, 2017)
	Composite reliability (COMR)	COMR ≥ 0.7	(Cronbach, 1951)
Convergent validity	Average variance extracted (AVE)	AVE ≥ 0.5	(Fornell and Larcker, 1981)
Discriminant validity	Fornell-Larcker criterion	The square root of AVE > correlation with other constructs	(Fornell and Larcker, 1981)
	Heterotrait-Monotrait Ratio (HTMT)	Constructs' correlation ≤ 0.85	(Henseler *et al.*, 2015)

Indicator reliability is expressed in terms of outer loadings of the model and has varying values between 0 and 1. Research conducted by various researchers has used a threshold value of 0.7 for indicator loading (Kamal *et al.*, 2020; Lee and Lehto, 2013; Park *et al.*, 2012). SmartPLS with 300 iterations were used and results are indicated in **Table 13**. All of the items exhibit an indicator loading of more than 0.7 and hence all the items are considered reliable.

Cronbach's alpha (CRA) and composite reliability (COMR) are used to assess construct reliability and threshold values for both cases are 0.7. As indicated in **Table 13** that all of the values are above the recommended threshold. The values of CRA ranged between

0.728 and 0.885 while that of COMR is in the interval of 0.888 and 0.945. The results indicate the high reliability of constructs of the proposed model.

Table 13: Results of Measurement Model Assessment

Construct	Items	Item Loading (≥ 0.70)	CRA (≥ 0.70)	COMR (≥ 0.70)	AVE (≥ 0.50)
Perceived usefulness (PU)	PU1	0.918	0.864	0.917	0.786
	PU2	0.910			
	PU3	0.829			
Perceived ease-of-use (PEOU)	PEOU1	0.868	0.877	0.924	0.803
	PEOU2	0.933			
	PEOU3	0.886			
Trust (T)	T1	0.935	0.885	0.945	0.896
	T2	0.958			
Social influence (SI)	SI1	0.907	0.774	0.898	0.816
	SI2	0.899			
Facilitating conditions (FC)	FC1	0.901	0.728	0.888	0.786
	FC2	0.871			
Technological self-efficacy (TSE)	TSE1	0.919	0.875	0.922	0.797
	TSE2	0.872			
	TSE3	0.886			
Behavioral intention to use (IN)	IN1	0.923	0.850	0.915	0.783
	IN2	0.85			
	IN3	0.857			

The average variance extracted (AVE) is the amount of variance explained by the latent variable. The threshold value for AVE is 0.5. The AVE values for all of the latent variables in the proposed model are more than the acceptable threshold of 0.5, ranging from 0.786 to 0.896. Moreover, trust exhibited the highest value for AVE. When the outer loading of each item is larger than 0.7 and the AVE values of each latent variable are equal to or greater than 0.5, convergent validity is attained (Hair *et al.*, 2011, 2014). As a result, we may conclude that all of the measurements are significantly related to the assigned latent constructs (see **Table 13** for reference).

Discriminant validity measures that two constructs in the model are significantly different and have a higher correlation with their indicators than the other constructs' indicators (Hair *et al.*, 2017). In the current study, two methods have been adopted to access the discriminant validity: 1) Fornell-Larcker Discriminant Validity and 2) Heterotrait-Monotrait (HTMT) Discriminant Validity.

According to the Fornell-Larcker discriminant validity criteria, the square root of AVE should be more than the correlation with any other constructs. **Table 14** demonstrates that the square root of the AVE of each construct is greater than the correlation with other constructs. The values in bold italic are the square root of AVE. Hence, all of the variables in the proposed model have discriminant validity, according to Fornell-Larcker criteria.

Table 14: Results of Fornell-Larcker Discriminant Validity

	IN	**FC**	**PU**	**PEOU**	**SI**	**TSE**	**T**
IN	***0.877***						
FC	0.513	***0.886***					
PU	0.497	0.577	***0.887***				
PEOU	0.545	0.603	0.551	***0.896***			
SI	0.333	0.526	0.507	0.516	***0.903***		
TSE	0.487	0.639	0.442	0.542	0.461	***0.893***	
T	0.523	0.618	0.463	0.474	0.483	0.618	***0.947***

The Heterotrait-Monotrait Ratio (HTMT) is another contemporary strategy for testing discriminant validity in the PLS-SEM technique (Henseler *et al.*, 2015). According to the HTMT approach, the correlation value among the constructs should be less than 0.85. The values closer to one mean the constructs are highly correlated. As revealed in **Table**

15 that all the values are lesser than the recommended threshold of 0.85 and hence constructs possess discriminant validity.

Table 15: Results of HTMT Discriminant Validity

	IN	**FC**	**PU**	**PEOU**	**SI**	**TSE**	**T**
IN							
FC	0.650						
PU	0.571	0.729					
PEOU	0.630	0.749	0.627				
SI	0.407	0.700	0.617	0.626			
TSE	0.558	0.801	0.483	0.602	0.546		
T	0.595	0.759	0.520	0.533	0.583	0.690	

The measurement models of this study have passed all the tests mentioned in **Table 12**. The next step is to test the structural model in this study.

5.6.2. Structural Model Assessment

The purpose of structural model assessment is to test the hypotheses established in the study by evaluating the relationship between model constructs. Several researchers have used only two criteria to test the structural model which includes the path coefficients and coefficient of determination (R^2) (Ifinedo, 2015; Monem and Shaalan, 2019; Nikou and Economides, 2017). The path coefficient indicates the direct effect of one construct on another, while the coefficient of determination (R^2) explains how much variation the endogenous construct explains. However, this study also implies testing the collinearity issues and cross-validated redundancy (Q^2) as suggested by (Akbari *et al.*, 2020; Hair *et al.*, 2019; Sukendro *et al.*, 2020). As shown, **Table 16** summarizes the criteria employed in the current investigation to test the structural model.

Table 16: Structural Model's Assessment Criteria

Criteria	Guidelines	References
Collinearity	Variance Inflation Factor (VIF) < 5	(Hair *et al.*, 2019)
Path coefficients (β)	Use bootstrapping with 10,000 subsamples Significance Value: $p \leq 0.05$ Sign: one-tailed option	(Hair *et al.*, 2017)
Coefficient of determination (R^2)	Weak effect: $R^2 = 0.19 – 0.33$ Moderate effect: $R^2 = 0.33 – 0.67$ High effect: $R^2 > 0.67$	(Chin, 1998; Salloum *et al.*, 2019)
Cross-validated redundancy (Q^2)	Blindfolding Technique $Q^2 > 0$	(Hair *et al.*, 2019)

Firstly, the collinearity issue is checked. Collinearity exists when exogenous variables of an endogenous construct are highly correlated and that results in interpretation issues. Collinearity issues can be predicted using the VIF values (Binyamin, 2019). **Table 17** demonstrates that the VIF values of all the independent constructs are well below 5. Hence, concluding that collinearity is not an issue in this study.

Table 17: Variance Inflation Factor (VIF) Values

CONSTRUCT	IN	PU	PEOU	T
BI				
FC		2.298	1.691	
PU	1.553			
PEOU	1.573	1.799		
SI		1.582		1.000
TSE		2.057	1.691	
T	1.395	1.937		

In the next stage, hypotheses testing was carried out. Using SmartPLS, the structural model was tested with 10,000 sub-samples at 5% significance. Because all of the hypotheses in this investigation were directional, a one-tailed t-test was used. The results of the hypotheses and construct relationships are summarized in **Table 18**. A total of 9 out of 11 hypotheses established in the study were proved significant.

Table 18: Results of structural model

Hypothesis	Path	Path Coefficient	*p*-value	Result
H1	PU → IN	0.198	0.020	Supported
H2	PEOU → IN	0.299	0.010	Supported
H3	PEOU → PU	0.247	0.014	Supported
H4	T → IN	0.290	0.006	Supported
H5	T → PU	0.088	0.250	Not Supported
H6	TSE → PU	-0.016	0.433	Not Supported
H7	TSE → PEOU	0.265	0.002	Supported
H8	FC → PU	0.281	0.020	Supported
H9	FC → PEOU	0.433	0.000	Supported
H10	SI → PU	0.197	0.048	Supported
H11	SI → T	0.483	0.000	Supported

The hypotheses that were supported include; H1, H2, H3, H4, H7, H8, H9, H10, H11 while H5 and H6 were rejected. It has been observed that PU ($\beta = 0.198$, $p < 0.05$) and PEOU ($\beta = 0.299$, $p < 0.05$) has significant positive effect on IN and this confirms hypothesis H1 and H2. PEOU was determined to be significant in positively affecting the PU ($\beta = 0.247$, $p < 0.05$), and this supports hypothesis H3. T also has a Positive influence on IN ($\beta = 0.290$, $p < 0.01$) and hence supporting hypothesis H4. Moreover, PEOU was significantly influenced by two exogenous variables: TSE ($\beta = 0.265$, $p < 0.01$) and FC ($\beta = 0.433$, $p < 0.001$) which in turn supports hypotheses H7 and H9. FC ($\beta = 0.281$, $p < 0.05$) is also affecting PU and thus confirming hypothesis H8. SI was found to have significant positive impact on PU ($\beta = 0.197$, $p < 0.05$) and T ($\beta = 0.483$, $p < 0.001$) supporting the hypotheses H10 and H11.

The models' explanatory powers were ascertained using the coefficient of determination (R^2). The values of the coefficient of determination are presented in **Table 19**. The R^2 of the endogenous variable ought to be 0.10 (Falk and Miller, 1992; Hair *et al.*, 2019). The R^2 values for behavioral intention to use, perceived usefulness, and perceived ease-of-use vary from 0.33 to 0.67, indicating that the predictive power of these variables is moderate, as suggested by Chin (1998).

Table 19: R^2 of endogenous constructs

Construct	**R^2**
Behavioral Intention to use	0.413
Perceived Usefulness	0.432
Perceived ease-of-use	0.405
Trust	0.234

However, the R^2 of trust lies in the interval of 0.19 and 0.33; and thus, indicating low predictive power. The reason for the low R^2 value of trust is that it has only one independent variable which is social influence. According to Hair *et al.* (2017), the R^2 value is dependent on the number of exogenous variables of a construct and increases with the increase in the number of exogenous variables. To conclude, the results demonstrate a sufficient level of R^2 value.

Finally, to forecast the predictive relevance of the structural model the Cross-validated redundancy (Q^2) was calculated using blindfolding. The Q^2 value of IN = 0.296, PU = 0.307, PEOU = 0.311 and T = 0.203. All of the values are greater than zero and hence it validates the predictive relevance of the endogenous constructs.

The only model fit criteria in the case of PLS-SEM is the standardized root mean square residual (SRMR) value (Alashwal *et al.*, 2017). The current model fit examination reveals that the standardized root means square residual (SRMR) appears as 0.063, signifying that the model had a good fit as the required cut-off value is 0.08 or less (Hu and Bentler, 1998). The structural model along with the path coefficients (β) and coefficient of determination (R^2) is shown in **Figure 5.8**. The solid line between the two constructs indicates that the relationship is significant while the dotted line indicates a non-significant relation, and thus, our established hypotheses have not been supported for this study.

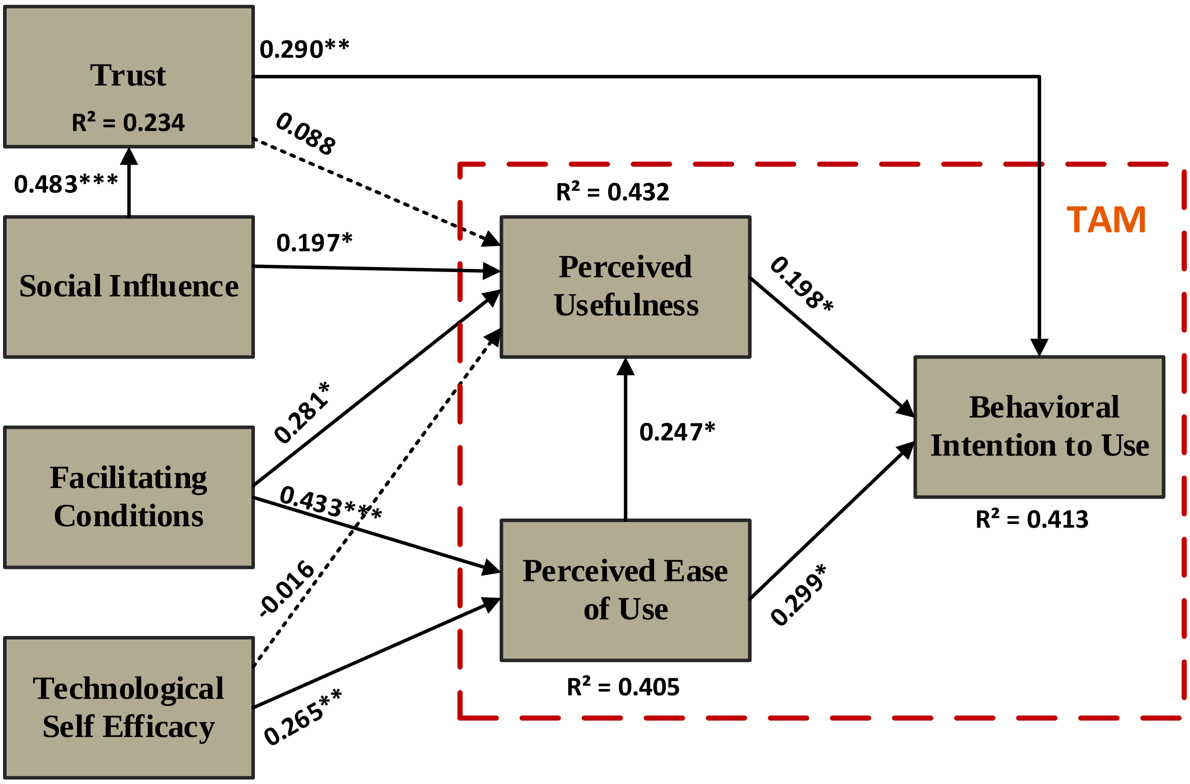

Figure 5.8: Results of Structural Model Including Path Coefficients and R^2.

5.7. Final Model

After following a multi-stage procedure for testing the measurement and the structural model in SmartPLS, final relationships of TAM constructs and external constructs have been identified. The hypotheses that were not supported were excluded from the final model. **Figure 5.9** shows the direct relation of various endogenous and exogenous constructs used in the proposed model with the empirical results of the hypotheses that have been supported in this study. The final model explains 41.3% of the variance in behavioral intention to use the E-IRS in the construction industry.

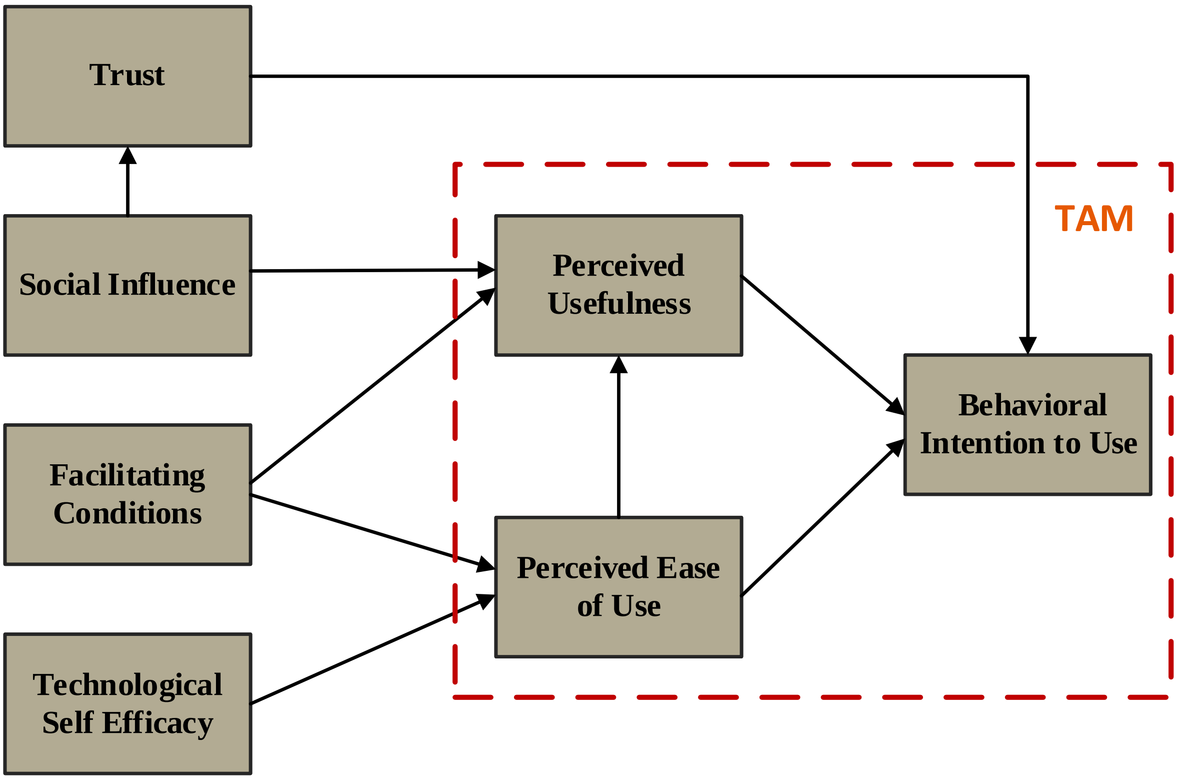

Figure 5.9: The Structural Model with Supported Hypotheses.

5.8. Discussion

This study aimed in finding the key drivers that would influence the use of E-IRS in the construction industry and validated the research model to determine the user intention for E-IRS in developing countries. The findings showed that the perceived usefulness of E-IRS had a significant positive effect on the behavioral intention to use the system. Also, it infers that perceived ease-of-use had a direct positive impact on both the perceived usefulness of the system and behavioral intention to use the system. The outcomes of this examination are confirming the prior research on this topic (Al-Rayes *et al.*, 2020; Ji *et al.*, 2019; Nikou and Economides, 2017; Salloum *et al.*, 2019; Wu, 2003). Besides, these results also support the original TAM (Davis, 1989). Hence, it translates that an individual's perceptions of the system's easiness and usefulness are important elements to enhance the use of E-IRS among the individuals in the construction industry. In other words, the construction employees hold a positive view of E-IRS when they have confidence that the system does not require mental or physical effort and is beneficial to use. Consequently, their motivation to utilize these services will enhance. In the current study, the influence of perceived ease-of-use on the adoption of E-IRS is more compared to the perceived usefulness. Therefore, it is vital to keep the system design and user interface simple and effortless to enhance the usage of the E-IRS in the construction industry.

Trust had a substantial positive impact on behavioral intention to use E-IRS which confirms the prior study of Wu (2003); that explored the impact of trust on behavioral intention to determine the acceptance of an adverse event reporting system in the healthcare setting. Moreover, this research indicates a non-significant impact of trust on perceived usefulness which is in contrast with the previous studies (Boon-itt, 2019; Tung *et al.*, 2008). Employees will be more willing to report an incident and use E-IRS if they are assured that there will be no privacy concerns and infringements. The output of the incident report should not lead to allocating blame but to learn from the mistakes and rectify them before a significant accident may occur. Therefore, to promote the willingness towards the use of E-IRS, it is pertinent that management instigates trust among employees and clear doubts that inhibit its usage.

Based on the hypotheses testing results, it is observed that technological self-efficacy is highlighted as an influential driver of perceived ease-of-use which leads to positive behavioral intention. This conclusion is in line with several prior pieces of research (Al-Gahtani, 2016; Chow *et al.*, 2012; Rezaei *et al.*, 2020; Wu *et al.*, 2007). However, in the perceptive of the construction industry, technological self-efficacy yields no consequences on the perceived usefulness of the system. This can be attributed to the general human behavior that persons' confidence in their experience, capabilities, and skills is closely related to their assessment of the difficulty or ease of using technology rather than their perception of its usefulness (Madorin and Iwasiw, 1999). If one is confident about his skills and use of technology this would ultimately reflect ease in using a particular system without much hassle. In contrast, if an individual considers himself less capable and exposes a negative tendency of using a particular system (i.e., E-IRS) then he may distinguish the system as less valuable and difficult to use. Therefore, employees in the construction industry should be given training about the use of E-IRS as it will help to lessen the resistance towards the its adoption.

This research concludes that facilitating conditions influences positively both the perceived ease-of-use and perceived usefulness of the E-IRS and hence, allow its usage in the construction industry. This confirms the previous research conducted by (Bryson and Atwal, 2013; Sukendro *et al.*, 2020). Facilitating conditions in the context of the current study include the provision of basic resources for the use of E-IRS which may include electricity, internet, technical support, and others that would help in assisting incident reporting. Without adequate resources and facilities, E-IRS could not be employed to fulfill the said objectives and would only create disturbance for its users.

Many of the previous researches who have examined the adoption of Information System (IS) technologies have combined factors identifying the social aspect of adopting new technologies and found a substantial impact of social influence on the successful implementation of novel technologies (e.g. Ji *et al*., 2019; Kamal *et al*., 2020; Tsourela & Nerantzaki, 2020). Regarding social influence, the data indicated that it had a vital role in promoting trust for the use of the E-IRS which is in agreement with the findings of prior studies (Wu, 2003). This research also showed that social influence yields a strong impression on the perceived usefulness of E-IRS. Therefore, if management supports its employees in using the system without any fear of punishment or blame; it will ultimately result in individuals reporting incidents and hence, uncluttering the possibility of identifying causes of future hazards. This advocates that robust administration support signifies a vital aspect of building a favorable atmosphere for system success and diminishing system users' unenthusiastic behavior towards it.

Chapter 6

IMPLICATIONS, CONCLUSION, AND LIMITATIONS

This chapter concludes the overall research findings obtained in this study. Firstly, the study implications including the theoretical and practical implications were discussed, followed by the research limitations, and finally, it recommends the areas for future research.

6.1. Theoretical Implications

This study contributes literature in the field of "health and safety" and "information system". Electronic incident reporting system (E-IRS) is still an evolving technology in the construction industry that has been relied on paper-based reporting phenomena, with insufficient prior knowledge on the topic in the context of the construction industry. This is the pioneer study designed to analytically survey the drivers of E-IRS in the construction industry, which was achieved by extending the TAM to look into the determinants of E-IRS acceptance. Successful E-IRS implementation requires a thorough understanding of the factors that influence its acceptance. Therefore, future researchers, designers, and managers interested in developing and implementing the E-IRS in the construction industry can use this research as a guide.

This study also supports the usefulness of the TAM coupled with external variables in forecasting the utility of E-IRS in the construction industry of developing countries. The strength of this research findings lies in extending the well-validated TAM theory with technological self-efficacy, facilitating conditions, social influence, and trust as additional antecedents to predict the users' behavioral intention. Moreover, this study collected data from developing countries around the world, and thus, it enriches the literature by portraying a picture of E-IRS adoption behaviors of individuals associated with the construction industry in developing countries. The research was conducted on the non-mandatory use of the E-IRS hence, it provided valuable insights about the adoption behavior in circumstances when users have the possibilities to use the system fully or partially or to not use the system at all. This flexible setting allows an in-depth explanation of the users' intentions towards E-IRS before its actual extensive implementation in the construction industry.

6.2. Practical Implications

According to the study, perceived ease-of-use is a significant factor that influences employees' E-IRS use behavior. As a result, designers and policymakers should focus their efforts on improving the quality of the E-IRS in order to make it productive in the construction industry. The user interface of E-IRS should be comprehensible and contain vital functions to reduce the user's reporting effort. Furthermore, user-friendliness, simplicity, and dependability are also critical considerations. The E-IRS's interface, navigation speed, functions, features, contents, etc., should be monitored and improved on a regular basis in accordance with the needs and acceptability level of users.

The study reveals trust as another crucial factor in determining users' acceptance of E-IRS. Reporting should feel safe and secure and should not have any negative consequences. The managers should advocate trust and confidence among the users when implementing the incident reporting system; that user will not face any penalty or retaliation from others as a result of incident reporting. Promoting a non-punitive reporting culture is thus a vital consideration for worker safety. Likewise, the focus should be on the human factor approach; which suggests looking into the organizational and environmental factors of the incident instead of leveling allegations against human beings. It is also suggested that the identity of the reporter should not be disclosed to a third party in order to ensure anonymity and confidentiality and to give confidence that reported information will not be used against them. When participants are more confident about using the system, the system is more likely to be accepted in the construction industry. In contrast, reporters may be less likely to use E-IRS due to scarce trust and negative publicity by others.

Managers should also promote the significance of having an electronic system to potential users for reporting incidents, as well as its main benefits, in order to enhance their trust in it, which could lead to increased E-IRS use in the future. Once the incident is reported experts must evaluate and analyze the incident to find the root cause and to generate meaningful learning outcomes in order to avoid the reoccurrence of such incident. Moreover, there is a need to disseminate information about critical events to inform reporters of any consequences resulting from these reported events in order to motivate the user's participation in such incident reporting systems (Staender, 2011). Lack of feedback is reported as an important barrier that inhibits the utility of reporting system. For employees to continue to participate in the incident reporting process, they must see something positive coming out of it. Therefore, in order to realize the usefulness of E-IRS, it is needed that the reporter is provided necessary feedback during the analysis of the incident and at any later stage.

Management should provide technical skills and basic computing training to workers lacking such resources and expertise given that technological self-efficacy may facilitate the use and adoption of E-IRS. An audio and visual aid, as well as animated simulations, could also be incorporated to support the users' participation in the system. According to our findings, social influence not only has a direct impact on perceived usefulness, but it also has the greatest effect in building trust to use E-IRS. Therefore, it is vital that management encourages the use of the system not just with words but also with positive actions. Management should also promote the system and educate employees that in case of an adverse event they should use the E-IRS to ensure safety for all the employees at the construction site. To assist reporting in becoming a culturally accepted activity in the construction industry, management must demonstrate visibly that they are keen to see people are satisfied with the use of the system.

Some important areas to focus on are; ensuring proper resources and facilities for effective incident reporting, such as high internet speed, power supply, system supported with latest hardware and software, etc. Decision-makers and technology staff should collaborate to identify and address users' needs and complaints to facilitate seamless use of E-IRS. These aspects should be taken into account not only during the development phase but also during the implementation phase of E-IRS and even in the potential future up-gradation of the system. Management should strive to enact policies and incentives that positively inspire attitude towards E-IRS in order to maintain favorable acceptance and use of the system in the industry. In this way, the construction industry will be able to take full advantage of the E-IRS.

6.3. Limitation and Recommendation for Future Research

This study provided key findings for construction safety theory and practice however, several limitations were identified that need to be mentioned. First, the respondents of this study were mainly professionals in the construction industry having adequate resources and English proficiency. Future studies should consider specifically the sharp end construction workers who are more likely to be involved in the incident, and thus, their BI towards the E-IRS is of greater importance for successful implementation of the system. Second, this study targeted the developing countries and consisted of a mixed sample with 58% of responses from Pakistan, which may have impacted the study's results. Therefore, forthcoming studies should investigate the acceptance of E-IRS using a research sample that is more representative of the survey population. Third, due to time and resource constraints, this research counted mainly on a quantitative survey approach for data collection from the respondents. Nonetheless, future research could consider using qualitative methods (e.g., focus groups and interviews) to gain a profound understanding of the examined problem and the behavior of the participants. Fourth, this research is based on a few external variables; other psychological and technological theories, as well as the effect of mediators and moderators, can be used to analyze the willingness to use E-IRS and to enhance the model's explanatory power. Finally, a similar study with a focus on developed countries should be conducted to compare the findings of this research. There is a fair chance that the results of such a study aimed at developed countries will differ from those aimed at developing countries due to the widespread integration of IT-based solutions in the construction industry of developed countries, as opposed to developing countries.

6.4. Conclusion

Many studies have emphasized the importance of incident reporting, although little research has explored and discussed the electronic incident reporting systems (E-IRS) in the context of the construction industry. This study aimed in understanding factors influencing the use of E-IRS and quantitatively confirmed the relationship between external variables (TSE, SI, T, FC) and TAM by proposing an extended TAM model. Accordingly, the PLS-SEM method was used to confirm the research model. It was identified that perceived ease-of-use and perceived usefulness are essential predictors of behavioral intention. Trust also emerged as a key predictor in promoting the usage of E-IRS. Therefore, designers and developers should create the system and its interface in such a way that it is useful and easy to use, which may augment the willingness to accept and adopt E-IRS. However, due to the limitations of this study, some attention is required when generalizing the findings of these results. The findings of this dissertation contribute to the existing body of knowledge about the development and implementation of E-IRS and also provides a theoretical basis for construction safety managers, designers, and all the concerned parties to take effective measures to encourage the use of E-IRS in the construction industry of developing countries, thereby reducing the likelihood of construction-related incidents.

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